COLLECTION OF GUTTA PERCHA.

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AND

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CAOUTCHOUC AND GUTTA PERCHA.

PART I.—CAOUTCHOUC.

CHAPTER I.

HISTORY OF CAOUTCHOUC.

The vegetable world supplies us with a few instances of products so important to mankind, whether in a state of civilization or otherwise, as to impress the strongest conviction that they were expressly created for his use. We find their applicability to man's purposes so complete, their utility so direct and evident, that the mind is carried irresistibly to the conclusion, that He who formed all created things for his own pleasure, and to beautify the world we inhabit, formed some which He intended to constitute his special gifts to the human family. If we look at the natural

family of the cereals, among which are included wheat, barley, oats, &c., we find a class of plants whose connexion with man, in temperate latitudes, and as high as from 55° to 60° N. lat., is so direct, apparent, and intimate, that it is plain they were formed for his special use, and for that of his brute dependants. The single article, rice, has been said to support by far the greatest number of the human race. What the cereals are to man in a state of civilization,—and indeed more, the palms are to the savage inhabitants of the palm-zone of the world. Wine, oil, wax, flour, sugar, salt, says Humboldt, are the produce of this single tribe; to which Von Martius quaintly adds, *thread, utensils, weapons, food and habitations.* To the indolent Polynesian the cocoa-palm is the all-in-all. The islander reposes beneath its shade; its fruit supplies him with food and drink; his dwelling is thatched with its ample fronds; its leaves form his baskets, its leaflets his fans and bonnets. Out of the fibrous material which envelops the base of the stalks, he prepares a coarse sort of cloth; the nuts furnish him with drinking vessels, the fibres with material for his cordage, the oil a balm for the living and for the dead. "The noble

trunk itself," says Mr. Herman Melville, "is far from being valueless. Sawn into posts, it upholds the islander's dwelling; converted into charcoal, it cooks his food; and supported in blocks of stone, rails in his lands. He impels his canoe through the water with a paddle of the wood, and goes to battle with clubs and spears of the same hard material." Well might Linnæus call this family the vegetable princes, and justly might the cocoa-palm wear the regal crown. These two families—the grasses and the palms—have, however, their chief relation with the direct necessities of human life. As man advances in civilization, his wants increase, and the supply of these wants is scarcely less a necessity, if his progress is to be maintained, than that of his daily food. To supply some of these wants, our age has witnessed the introduction of the remarkable substances at the head of this book. Applicable to a multitude of purposes directly concerned in carrying forward the business of civilized life; yielding readily to manipulation; combining qualities possessed by no other materials, and capable of being obtained in sufficient abundance, caoutchouc and gutta percha form

an excellent illustration of the proposition with which we commenced this paper.

If we are to credit M. Duchesne, and most authors who have had to speak of caoutchouc, we must attribute to the French nation the sole merit of its discovery, and of its introduction to the notice of the European world. Four Frenchmen, observes M. Duchesne, have united in the course of half a century in giving descriptions of the tree which furnishes this substance, and the concrete juice which exudes from it, so as to render our knowledge of this subject now complete. The first of these was M. De la Condamine. This gentleman, who was a French academician, having been despatched in company with M. Bouguer on a scientific mission to the interior of South America, became acquainted with the tree yielding it, and also with the method of its collection, and forwarded a short note of the fact to the Academy of Sciences in 1736. Subsequently, he furnished a longer statement, which gave a greater detail upon the processes, and the cultivation of the tree: and this has generally been considered to have been the first introduction of any accurate information upon this important substance into Europe. It is,

however, deserving of notice, that the knowledge of this substance, and of some of its properties, reached Europe long before the visit of these academicians, for caoutchouc was known at the early part of the last century. And if there be any merit in having been the first to give an account of the substance, it must be taken from the ingenious Frenchman, M. De la Condamine, and given to a Spaniard, Torquedama, whose work was published in the latter part of the sixteenth century. This account is so concise and interesting, that no apology need be made for its introduction into our pages. "There is a tree," he writes, "which the Indians call Usquahuitl; it is held in great estimation, and grows in the hot country. It is not a very high tree; the leaves are round and of an ashy colour. This tree yields a white milky substance, thick and gummy, and in great abundance. To obtain it, they wound the tree with an axe or a cutlass, and from these wounds the liquor drops. The natives collect it in round vessels of different sizes, called in their language, Xicalli, but by us calabashes. In these they allow it to settle in round balls of the size most convenient for the purposes to which they

are about to apply them. When quite set, they boil them in water, in which state the gum is called Ulli. The Indians who have got no calabashes, smear their bodies over with it, (for nature is never without a resource,) and when it becomes dry, they remove the whole incrustation, which comes off in the form of a very smooth membrane, its thickness depending upon the will of the party collecting. They then make it into balls, and boil them as before. Anciently they used to play with these balls, striking them against the ground, and making them rise to a great height. But in the game of the Pelota, it was not struck against the ground, but caught upon the hip or shoulder. From the ulli an oil is extracted of great value in various applications. It was formerly much used by the natives, nor have they forgotten its properties now; for it is soft and lubricous, and of especial effect in removing any tightness of the chest. The oil is extracted from the ulli by heat; it starts out in a manner to excite admiration, leaving me nought to compare it unto. The oil is drunk mixed with cocoa, and indeed it softens any other medicine, however hard its quality. It is also found of great service in

stopping hæmorrhage, for which it is taken internally. The coagulated ulli is so strong in itself, that a breastplate made of it no arrow will pass through; for being of a nature leathery and membranous, it ejects the point. The kings and the nobles were accustomed anciently to *make shoes of the ulli,* and to order their fools and jesters, the hump-backed and dwarfs of the palace, to be shod therewith, in order to make them sport, for the wearers could not step without falling, which, with their awkward actions, gave rise to much jesting and merriment." What, we may ask, would be the surprise of this learned Spaniard, were he to behold our modern over-shoes made of the same substance?—the wearers of many of which find, particularly on the greasy pavements of our streets, that the ancient cause of merriment still survives, in the slipperiness of their gait. "Our people," continues our author, *i. e.* the Spaniards, "used it in waxing their cloaks, which were made of coarse canvas, so as to *make them resist water;* and in truth it is of great effect in resisting the water, but not so the sun, for the rays thereof melt it." From this paragraph we learn that india-rubber water-proof cloaks were in use nearly two centuries

before the mackintosh, and that their first inventors were the Spaniards. The whole of this account is highly interesting, as it proves that from time immemorial the savage people inhabiting the luxuriant virgin forests of South America, have perceived the value and applicability of this substance to the purposes of life. The account leaves no doubt in the mind, that to the Spanish nation, rather than to the French, the honour of the first published and complete account of caoutchouc is to be awarded.

Returning to M. De la Condamine, we find him in the glorious woods which overshadow the deep waters of the Mazanon. Here, where as he says the multitude and diversity of plants and trees that he met with would furnish ample employment for many years, for the most laborious botanist and artist, he fell in with the trees yielding caoutchouc. The best idea of the place is furnished in his own description of it. Amid trees whose tall summits fathomed the very heavens, the Lianes crept about like cables. These plants grow up winding round the trees and shrubs they meet, and being arrived at their branches, they shoot out threads or filaments, which, falling down in

a perpendicular line with themselves into the earth, take root afresh, grow up again, ascending and descending alternately; others again are carried obliquely by the wind, fasten upon the neighbouring trees, and form a confusion of living cordage, hanging down and extending every way, which yields the eye a prospect very like that of a ship's tackling. Some are as large, and even larger than a man's arm; some choke the tree round which they cling, and make it actually die away by winding themselves so hard about it, which has caused the Spaniards to call these plants the wood-killers. Sometimes the trunk thus killed is pierced with insects, and rots away, so that there remains only the graceful spirals of the deadly Liane, forming a kind of wreathed column, self-supported, and producing a most elegant and fantastic appearance. In the midst of such scenes of vigorous life, of death and decay, where the children of the earth contend with one another for existence, and grow luxuriant upon every inch of the fruitful soil, the caoutchouc tree was found by the French academicians in 1736. A mere touch of a knife in the bark of a number of trees in this prolific region, sets free the burst-

ing juices, and gums, resins and balsams, stream in profusion down their glistening sides. Among them, and the most singular and valuable, occurred the caoutchouc. The following is De la Condamine's own account of this substance. "The rosin named Cahout-chou in those countries of the province of Quito adjacent to the sea, is very common also on the banks of the Mazanon, and serves for the same uses. When it is fresh they work it with moulds into what shape they please, and it is impenetrable by the rain. But what renders it the most remarkable, is its great elasticity. They make bottles thereof, which it is not easy to break; boots and hollow bowls, which may be squeezed flat, and when no longer under restraint, resume their first form. The Portuguese of Para have learnt of the Omaquas to make squirts or syringes thereof, that have no need of piston or sucker; they are made hollow in the form of a pear when scooped, having a little hole at the small end, to which a pipe of the same size is fitted, they are then filled with water, and by squeezing them they have the same effect as a common squirt! This machine is mightily in vogue amongst the Omaquas; when they meet together by themselves for

any merry-making, the master of the house never fails to present one to each of his guests; and the use of the squirt with them is always the prelude to their most solemn feasts." This instrument is now most extensively employed in medical practice in our own age, and is sometimes spoken of as though it were a discovery due to the ingenuity of our modern mechanicians. The whimsical custom in question led the Portuguese to call the tree that produced the substance from which the syringes were made, Pao di Xirringa, a name still retained, as the trees are often called in America, the Seringa trees.

M. De la Condamine, being unable to prosecute further inquiries upon this subject, it was investigated by a M. Fresneau, an engineer, who had spent many years at Cazenove, in Guiana. Having seen a number of curious things made of caoutchouc, which were brought by the Portuguese and Indians from time to time to Para, he became extremely desirous of discovering the tree yielding so remarkable a material. He made a number of inquiries of the Indians, offering them valuable presents for any intelligence they would furnish him as to these trees. Failing to elicit the least informa-

tion from them, he determined to hunt out the trees for himself. For a long time all his attempts were fruitless. Meeting, however, ultimately with some fugitive Indians, he obtained from them the desired information. Finding that it was impossible for him to go in person to the places indicated, he got these Indians to model in clay the fruit of the tree, and to give him an idea as to its leaves. These clay models M. Fresneau sent to various persons stationed in different parts of the country, requesting to know if any trees produced such fruit in their vicinity. His ingenious plan was at length successful, and the gratifying intelligence reached him that the precious trees had been discovered. Immediately he departed, and quickly recognised the tree he was in search of, and the same day made a successful experiment with its wonderful sap. Ultimately, he discovered a number of trees, and returned from his mission laden with a pair of caoutchouc boots, some elastic bottles, bracelets, &c. An account of his undertaking was published by the French Academy in 1751.

Subsequently, M. Aublet, who published a valuable work in 1775 upon the plants of Guiana,

gives a very tolerable botanical account of the tree, which he had not the opportunity of seeing when flowering. He mentions that the fruit was eatable, and was much sought after by the natives. He partook also of the same fruit without experiencing any inconvenience from his repast. He gives the following statement of the method adopted for the collection of caoutchouc:—" The natives begin by making at the bottom of the trunk a deep gash, which penetrates into the wood. They then make another incision from the upper part of the trunk vertically downwards to the former one, and at various distances a number of oblique incisions are made, running into the first. These incisions form channels for the oozing sap, and convey it into a vessel placed for this purpose at the foot of the tree. In this the sap collects, loses its moisture, and becomes a soft elastic mass, which, when quite fresh, is readily made to take the shape of any instruments or vessels upon which it is applied, layer by layer. These are then dried by exposure to the fire. The moulds are sometimes made of unbaked clay, and are then removed by pouring in water, which softens them, so that the caoutchouc alone remains.

Sometimes they are made of baked clay, and are removed by being broken to pieces, the elasticity of caoutchouc enabling it to bear the violence necessary, without injury to its structure." M. Richard, the eminent botanist, completed the account of the tree, and described its true botanical characters.

Caoutchouc continued long to remain an article chiefly confined to the cabinets of the curious. Its extraordinary properties were the admiration of a few learned persons, for the greater part of the last century, and there appeared little prospect of its ever becoming applicable to the purposes of ordinary life. It was known hitherto only as a product of Cayenne in Guiana, and other countries on the eastern coast of South America, and was called, from its properties of removing marks of dirt or pencils upon paper, by the English, India-rubber, by the French, *peau de nègre.* Much investigation was directed into its properties by the scientific, as it was easily perceived that, could it be made amenable to treatment, it gave promise of becoming one of the most useful and valuable substances. The attention of the French chemists was largely occupied with a

variety of experiments, undertaken with a view to discover a menstruum in which this intractable material might be made to dissolve. In the Memoirs of the Academy of Sciences are repeated accounts given of the difficulties of the undertaking, and of the limited degree of success which attended it. The grand object was to discover some fluid which would restore the solid caoutchouc to the same, or a similar state of fluidity, with that possessed by it on its first flowing from the tree. M. Macquer, after a prolonged series of experiments, discovered that caoutchouc was soluble in the purest ether, at the ordinary temperature, and the solution was transparent, and of an amber colour. Upon this solution being thrown into water, it was decomposed, and there rose to the surface a thin pellicle of caoutchouc, possessing most of the properties of that substance in its natural state. M. Macquer was successful also in applying this solution to the manufacture of tubes and other instruments. In order to form it into small tubes, he adopted the following ingenious method. He formed his mould of wax of the desired shape and size, and then dipping a pencil into the ethereal

solution of caoutchouc, he daubed the mould with it till he had covered it over with a coat of caoutchouc of sufficient thickness. The whole piece was then thrown into hot water, by the heat of which the wax was soon melted, and rose to the surface, leaving the caoutchouc tube completely formed behind it. M. Grossart, a subsequent experimenter, states that he succeeded very well in employing the essential oils of turpentine and lavender as a solvent for caoutchouc, and thus forming it into tubes, or giving it any shape that might be desired. M. Grossart, by an unaccountable perversion of ideas, declares that he succeeded in dissolving it by means of water. An examination of his experiment proves that he mistook the effects of heat upon this substance, for the softness of incipient solution. No experiment has succeeded in restoring caoutchouc to its original fluid state, the state in which it flows from the tree.

Meanwhile, other sources of this substance were discovered. It was heard of in Guinea, in China, in Sumatra, and in many of the East Indian islands and provinces. As its production became more universally known, its use became also more universal, and it ceased to be regarded as a curi-

osity. It was now beginning to be imported from America, and subsequently it formed an article of East Indian commerce, from which regions at the present time large supplies are derived. About the end of the last century an English gentleman—a surgeon—Mr. Howison, endeavoured to render caoutchouc more universally applicable to the wants of civilized life, and being then a resident in one of our East Indian settlements, he undertook a series of experiments with this view. He discovered a tree whose milky juice yielded it in abundance. He contrived to make boots, gloves, and a number of articles of dress by first forming moulds of wax of the required shape, and then coating them over with the liquid juice gathered for this purpose, and preserved in hermetically closed bottles, by which for a short time it could be kept in a liquid state. He also dipped in the juice an elastic cloth, hoping to be able to produce a waterproof fabric. This experiment proved perfectly successful, and he had the novel gratification of preparing for himself a complete waterproof suit of clothes, sufficiently elastic for comfort and wholly impervious to moisture. These experiments were sufficiently

singular in their results to attract notice, and much interest on the subject of caoutchouc was excited. Dr. Roxburgh being at the same time in India, his attention was drawn to the subject, and he published a botanical account of the tree yielding the substance. Some years later, a friend sent this gentleman a vessel called a Jurong filled with honey in the very state in which it had been brought from the Pundua or Juntipoor mountains north of Silhet. This vessel was a common, or rather coarse basket in the shape of a four-cornered, wide-mouthed bottle, made of split rattans, several species of which grow in abundance amongst the above-mentioned mountains, and contained about two gallons. Dr. Roxburgh's friend drew his attention to the fact that the inside of the vessel was smeared over with the juice of a tree which grows in the mountains. He was therefore more anxious to examine the nature of this lining than the quality of the honey. The jurong was emptied out, and to the gratification of Dr. Roxburgh, he found it very perfectly lined with a thin coat of caoutchouc. On inquiry, the tree yielding it was discovered, growing in the chasms of the rocks in mountain declivities. The milk obtained by inci-

sion, while in its recent, undecomposed state, was employed by the natives of these mountains—in other respects a most barbarous and ignorant race—to coat the inside of such of their rude utensils as were employed to hold fluids. The same substance in its solid state supplied them with candles. They informed Dr. Roxburgh that they did not know of any mode by which it could be dissolved after it had once solidified.

While fresh sources of this wonderful substance were being continually discovered, the problem of its solution remained still unresolved. A little consideration and microscopic examination of the fresh juice might have informed those who sought to restore it from its indurated to its former milk-like condition, of the futility of the attempt. They might as easily have turned the curd of milk back to its original state in the fresh fluid, as thus affect caoutchouc. As we shall again have occasion to observe, the coagulation and separation of the liquid caoutchouc is a process which nothing can prevent, and it were as rational to attempt the re-solution of the coagulum of the blood, and the restoration of its separated constituents to their pristine state, as to hope to effect a similar change when caout-

chouc is once separated into clot and whey. The experiment was however the chimera of many ardent minds at the commencement of the present century. If success were possible, the reward was so certain to follow the discovery, that no wonder that many eager speculative chemists threw all their energies into the investigation. We have been told of one, a young student of medicine, who, bent upon the search, hired a lonely attic in a poor quarter of a great city, and there laboured hard to accomplish the object he had in view. It was of necessity that such attempt should be wholly without success—caoutchouc could never be made to return to its once milky state. The investigation was not unlike that after the philosopher's stone. All these experiments were not however without some fruit. The lonely student in his garret is said to have been the inventor of one of the most important methods of treating caoutchouc now employed. A cheap, abundant, and effectual solvent was discovered by him, and by others about the same time; and the attempt to reduce solid caoutchouc to its original state of milk was finally abandoned. The medium employed for this purpose was what is commercially

known as naphtha, or spirit of tar; and this is now in common use at the present day. For some time, however, no progress was made in the manufacture of any article from this solution. The subject appeared to have been forgotten by the majority. Mr. Mackintosh was however long in experimenting upon it, and having at length completed his investigations, and successfully applied the solution to the production of waterproof articles, he applied for a patent for his invention, and shortly after, the valuable articles of dress now possessing a universal celebrity, called after their inventor's name, came into extensive use. From this time a number of minor improvements in the manufacture, and of fresh and important applications of the material, have raised caoutchouc to its present valuable position. To one of the most singular and successful modifications of this material—vulcanized caoutchouc—we shall have presently to advert. This is, however, to be said, that the desirableness of manufacturing waterproof clothing from the fresh milk appears to us still to remain. Although a portion of the offensive odour of the solvent disappears in time, yet mackintoshed articles always retain with

obstinacy an unpleasant, and to some an intolerable odour. For our own part, we see no difficulty in establishing a waterproof manufactory on the banks of the Amazon or Maranon. The Americans have set us the example of a successful manufacture of shoes on the spot where the juice can be had fresh, and a very little additional machinery, which might be worked by water-power, would enable them to turn out a beautiful impervious fabric, lighter than the ordinary Mackintosh, and entirely destitute of its offensive peculiarities. Mr. Howison's method was to lay a piece of cloth smoothly upon a table, and then pouring the fresh milk upon it, spread it evenly with a ruler and hang it out to dry. But one of the spreading machines which we have presently to describe, would do the same work far more effectually, and could get through a large quantity in a day. A material thus prepared would of course not fall within the prohibitory limits of any existing patent, for it is as old almost as the discovery of America itself. Cajeput oil has been recommended as a solvent for caoutchouc, but its expense is too great, and were it otherwise, its odour is far from being agreeable.

CHAPTER II.

BOTANICAL HISTORY.

It may appear singular that the vegetable nature of caoutchouc should ever have been questioned; yet it is certain that many philosophers ridiculed the idea of its being a botanical product, and considered it somewhat of a mineral. This curious idea was at length dispelled by Dr. Roxburgh, who fully confirmed M. De la Condamine's statement, that it was the inspissated juice of a tree, and carefully described the trees which yielded it. Its botanical history is interesting, and can now be given complete. The Indian caoutchouc is principally obtained from the natural family, *Artocarpaceæ*. The American, on the contrary, is derived from trees which are classed by botanists among the *Euphorbiaceæ*. The most important source of the East-Indian caoutchouc is the *Ficus elastica*, a relative of that

magnificent tree, the banyan, so famed for its "pillared shade, whose daughters grow about the mother tree." The *Ficus elastica* belongs to a species of plants which yield in abundance a milky juice, possessed of various properties. Some of the species are among the most formidable, as regards the properties of their juice and produce of vegetable productions. Others are harmless, or even useful and agreeable. The *Ficus elastica* is described by Dr. Roxburgh as a tree growing to the size of an English sycamore. It is called Karmeer by the inhabitants of the Pundua and Juntipoor mountains, which bound the province of Silhet on the north, where it is indigenous. It is also found in Assam, between the Burrampooter and the Bootan hills. It is a handsome tree, with an erect trunk, growing sometimes as large as to be six feet and upwards in circumference. It grows with great rapidity; a tree only four years old having attained the height of twenty-four feet, its trunk being three feet in circumference. Its leaves are very beautiful, well-formed, smooth, polished, and of a lustrous green. From the larger branches roots descend to the earth, as is the case with many other members of the

same family. The situations in which it flourishes are peculiar. It is principally found in rocky chasms; its roots plunged among the *débris* of mountains and vegetation, and here it elaborates that wonderful liquid which yields the caoutchouc in such abundance. The plant is now common in our hot-houses, and we have seen several fine specimens in the large conservatories. In that at Kew are some fine healthy trees of this species. Dr. Roxburgh says that old trees yield a much richer juice than the young ones. It is also stated to be a curious fact, that the juice of the latter remains much longer in its fluid or undecomposed state than that of the former, from which it would appear to follow that a larger proportion of caoutchouc was contained in the sap of the older trees than in that of the younger ones. The milk sap is extracted by incisions across the bark, down to the root, at a distance of about a foot from one another, all round the trunk or branch, up to the top of the tree; and the higher incisions, singularly, are said to yield a much larger supply of the valuable fluid than those lower down. After one operation, the same tree requires about a fortnight's rest, when it may be again repeated.

During the cool season, from October until March, the juice is more scanty than in the warm weather, from March to October, but it is then also richer. When the sap is exposed to the air, it separates spontaneously into the firm, elastic caoutchouc, and a disagreeable smelling whey-coloured fluid part. Fifty ounces of the pure milky juice, taken from the trees in August, yielded exactly fifteen ounces and a-half of the clean-washed caoutchouc.

In addition to the *Ficus elastica*, other trees, natives of India, yield caoutchouc. Among these are the Tak-tree, *Artocarpus integrifolia;* the Banyan tree, *Ficus Indica;* and the Pippula tree, *Ficus religiosa.* In the countries eastward of Bengal other sources of it have also been found; among these is a scandent mango, called *Luti Aru,* a beautiful description of climbing apple, called *Sadal Kowa.* These abound in a milky fluid, which contains a large proportion of caoutchouc. The *Urceola elastica,* first described as the chief source of caoutchouc in India, by Dr. Roxburgh, also yields it in abundance. In all these instances the substance is the same, but in none does it appear so perfectly formed, and of so good a

quality, as that obtained from the milk-sap of *Ficus elastica*, which has now come to be generally recognised as *the* Indian-rubber tree of the East Indies. Professor Royle, who has paid much attention to this subject, and to whom India is deeply indebted for the present importance of many of her commercial products, has long been endeavouring to gain public notice for the vast supplies of caoutchouc which that country is capable of affording. He states that in the East there might be any quantity of the article procured from a great variety of plants, if the natives could only be induced to collect it with sufficient care. The South American caoutchouc is generally collected with so much greater care than that from the East Indies, that it bears a much higher price in the market. That from India is, it is true, of an excellent quality, but it is generally so much mixed with a considerable quantity of dirt, bark of the tree, and other extraneous matter, as to be almost useless for the purposes of the manufacturer. So impure, indeed, is the majority of the East-Indian caoutchouc, that it cannot be turned as such to any useful purpose whatever, and can only be employed for the pur-

pose of distilling from it the volatile spirit, *caoutchoucine*. In 1836, East-Indian caoutchouc was selling in the market at twopence a pound, whilst that from Para fetched from 2*s.* 6*d.* to 3*s.* a pound. Caoutchouc is abundant also in the southern parts of China, and is exported from the island of Singapore. The Mauritius, Madagascar, Java, Penang, and other islands and countries of the East, abound in caoutchouc-yielding trees; whose juice is so extremely valuable that it is a matter of no little surprise that the negligence of the natives should be allowed to continue the sole obstacle to its extensive importation from these localities. Latterly, however, there has been a vast improvement in the character of the imported caoutchouc of Eastern India, and large quantities have been brought into the market, of so excellent a quality, as to have reduced the price of that from Para more than thirty per cent. There was, for a long time, a singular apathy about the development of this commercial resource of India. A parcel of it was sent, in 1828, from Assam, to a principal agency-house in Calcutta, and, strange enough, the house was puzzled to know what to make of the article,

and returned answer to the zealous collector who had forwarded it, in sanguine expectation of its rapidly assuming a high commercial importance, "The article being unknown in the Calcutta market, we are sorry we can give you no idea of its value." Caoutchouc was then selling in London at 2*s.* a pound. There has been a little revolution in the minds of commercial men since then even in India, for in 1838, 925 bazaar maunds of caoutchouc, value 7,400 rupees, were exported.

The South American caoutchouc is chiefly, if not exclusively, obtained from a tree belonging to the acrid and dangerous family of plants, the *Euphorbiaceæ.* The name given to this tree is variously, the Syringe tree, or the *Siphonia elastica,* or by the Americans, the Rubber-tree; the names *Siphonia* and *Seringa* have an evident allusion to some of the purposes for which caoutchouc is employed. The tree grows luxuriantly on the banks of the Amazon and its tributaries. It is described as attaining a very great height, being, at the same time, perfectly straight, and having no branches except at the summit, where they form a conical crown. Its leaves are not unlike those of the manioc, are coriaceous, and highly

polished on both sides. From its seeds an oil is extracted, which forms, it is said, a substitute for butter among the Indians.

Before closing our summary of the botanical history of this material, it is useful to notice the fact, that caoutchouc is a substance far more widely diffused among plants than has hitherto been considered. In addition to the two families which yield the caoutchouc of commerce, the *Artocarpaceæ* and the *Euphorbiaceæ*, caoutchouc has been discovered in the sap of plants belonging to the *Cichoraceæ*, *Lobeliaceæ*, *Apocynaceæ*, and *Asclepiadaceæ*. Several plants belonging to these families are employed in the manufacture of lime. Professor Royle says it is singular, that in these same families should be contained the several plants on which the silk-worm feeds, when unable to obtain its favourite food, the leaf of the mulberry. Thus in Europe it is fed on the leaves of the lettuce and dandelion, which belong to the *Cichoraceæ ;* so in India, the leaves of *Ficus religiosa*, of the family of *Artocarpaceæ*, has been found the best substitute for the mulberry leaf. A caterpillar which very large cocoon of a kind of tough, k, feeds upon the leaves of the South

American caoutchouc tree, *Siphonia elastica.* Considering such facts were not likely to be accidental, Professor Royle was led to suppose that this substance, caoutchouc, might possibly form a necessary ingredient in the food of silk-worms, and be in some way employed in giving tenacity to their silk. He, therefore, inferred that caoutchouc might possibly be found in their favourite food, the mulberry leaf, and requested M. Sievier, who has paid much attention to caoutchouc, to ascertain the fact. In a short time the conjecture appeared to be established; the sap of the mulberry leaf was found to be milky, and to contain caoutchouc. This subject has its importance, for it gives us somewhat of a clue to successful management of this fastidious but invaluable insect. The number of plants suited to silk-worms may, probably, be increased, by experimenting on those belonging to families which yield caoutchouc. It does not, however, by any means follow, that all which yield this principle are adapted for its food, since some contain in addition, as we have already noticed, a highly pernicious and acrid principle, which would, of course, render them unsuitable for such a purpose.

In a good article on the India-rubber productions shown at the Great Exhibition of 1851, and published in the *Athenæum*, occur the following sentences, which deserve extraction.

"Many of our British weeds yield, when pressed, a milky juice,—and there are few persons who have not observed this property in the garden spurge and in the common dandelion. Although regarded very generally with suspicion, the milky juices from the plants are not poisonous. Besides the two that we have mentioned, there are many other plants in our own country which yield the same white juice; and—as in the case of the poppy—these sometimes contain a poisonous constituent. These plants of Great Britain are local representatives of a vast multitude which under tropical suns in Asia and in America yield when they are wounded a milky juice. Humboldt in the first edition of his 'Aspects of Nature' noticed that the milky juices of plants increase as we approach the tropics. Little did he think at that time that the substance which gave the milkiness to the sap of tropical plants would become one of the most valuable contributions of the vegetable kingdom to man:—his best safeguard against the inclemency

of weather,—one of the most useful materials of his dress,—the protector coating of his electric telegraph wires beneath the sea,—his ready servant in the laboratory and in the construction of instruments for the relief of disease,—and offering to him the means of rest upon a bed of water, when all other human means have failed. Yet, such is Caoutchouc,—the substance which, diffused through the juices of plants, gives to them their milky appearance."

We have lately been favoured with some rambling notices of the Rubber-trees, a manufacture of America, in the graphic and interesting voyage of Mr. Edwards up the Amazon. Throughout the province of Para, the title of caoutchouc is universally disused, and the more elegant term seringa, or the more vulgar one, rubber, is employed to designate this substance, and the trees which yield it. Standing in the water, or imbedded in rich ooze, the seringa trees are recognised by their light grey bark, all scarred over with wounds. A passing cut at some of them instantly sets free the milky sap, and the white stream runs down the trunk. In the midst of these seringa trees are the wretched habitations of

the gum collectors. These were merely roofed or thatched on one side, and very often the water rose to the very door. No fruit-trees of any sort were there, nor was there sign of cultivation. The forest around was just sufficiently cleared to avoid danger from the falling trees, or to let in a glimpse of the sun. In these miserable places were always families, and thus they live all the year round, eating nothing but fish and farinha, and their situation only bettered in summer by its being less damp. The seringa tree abounds in those moist and unwholesome regions, and indeed along the whole course of the Amazon, probably to its head waters. High up this vast stream the demand has not yet been felt, and the rubber is only employed medicinally, being applied when fresh to inflamed parts. There exists, consequently, an enormously large area, in which these trees abound, the riches of which it remains for another generation to develop. When the rubber is wanted, enough can be forthcoming to coat the civilized world. Writing of one of the islands visited on his return, Mr. Edwards thus describes the locality of these important trees:—"This island was covered with a fine forest, in which

were abundance of seringa trees, all scarred with wounds. We made some incisions with our tresados, and the milk at once oozed out, and dripped in little streams. Its taste was agreeable, much like sweetened cream, which it resembled in colour. These trees were often of great height, and from two to three feet in diameter; the trunks were round and straight, and the bark was of a light colour, and not very smooth; the wood was soft, and we easily cut off a large root, which we brought away with us. The top of the seringa is not very wide-spreading, but beautiful, from its long leaves, which grow in clusters of three together, and are of oblong ovate shape, the centre one rather more than a foot in length, the others a little shorter. These leaves are thin, and resemble in no respect the leaves of an East-Indian plant, often seen in our hot-houses, and called the caoutchouc. There is, probably, not a true seringa in all the United States." By this we perceive Mr. Edwards must be wholly ignorant of the fact that the East-Indian caoutchouc is obtained from one natural family of plants, the South American from another. Since the term seringa was first given by the Portuguese

to the very trees of which Mr. Edwards is writing, and which are, unquestionably, the *Siphonia elastica*, it is incorrect to state, as stated in the last paragraph. "Around these trees were many of the shells, *Ampullarias*, used in dipping the gum, and also some of the mud cups, holding about half a gill each, which are fastened to the tree for the purpose of catching the gum as it oozes from the wound. We found also the fruit of the seringa; it is ligneous, the size of a large peach, and divided into three lobes, each of which contains a small black nut. These are eagerly sought by the animals, and although the ground was strewed with fragments, it was with great difficulty that we found a pair in good preservation. Specimens of all these things, wood, leaves, shells, cups, and seeds, we secured."

Between Santa Anna and Para, upon the small river Mojee, Mr. Edwards found a regular manufactory of those somewhat dangerous articles of apparel — the American rubber over-shoes, or goloshes. His account of the processes employed in their formation is so fresh and interesting, that henceforth no history of caoutchouc will

be complete without it. While waiting the tide, Mr. Edwards was conducted into a manufactory of these articles close by. The man of the house returned from the forest about noon, bringing in nearly two gallons of milk, which he had been engaged, since daylight, in collecting from one hundred and twenty trees that had been tapped on the previous morning. This quantity of milk, he said, would suffice for ten pairs of shoes, and when he himself attended to the trees, he could collect the same quantity every morning for several months; but his girls could only collect from seventy trees. The seringa trees do not grow thickly usually, and such a number may require a circuit of several miles. In making the shoes, two girls were employed, in a little thatched hut, which had no opening but the door. From an inverted water-jar, the bottom of which had been broken out for the purpose, issued a dense column of white smoke, from the burning of a species of palm nut, and which so filled the hut that its inmates could scarcely be seen. The lasts used were of wood, exported from the United States, and were smeared with clay to prevent adhesion. In the

leg of each was a long stick, serving as a handle. The last was dipped into the milk, and immediately held over the smoke, which, without much discolouring, dried the surface at once. It was then redipped, and the process was repeated a dozen times until the shoe was of sufficient thickness, care being taken to give a greater number of coatings to the bottom. The whole operation, from the smearing of the last to placing the finished shoe in the sun, required less than five minutes! The shoe was now of a slightly more yellowish hue than the liquid milk, but in the course of a few hours it became of a reddish brown. After an exposure of twenty-four hours, it is figured in various ways. This is done by the girls with small sticks of hard wood, or the needle-like spathes of some of the palms. Stamping has been tried without success. The shoe is now cut from the last, and is ready for sale, bringing a price of from ten to twelve cents a pair. In England we pay from 8*s.* to 10*s.* per pair. It is a long time before they assume the black hue. Brought to the city they are assorted, the best being laid aside for exportation as shoes, the other as waste rubber. The proper designation for this latter, in which are

included bottles, sheets, and any other form excepting shoes, is *borăcha,* and this is shipped in bulk. There are a number of persons in Para who make a business of filling shoes with rice, chaff and hay, previous to their being packed in boxes. They are generally fashioned into better shape by being stretched upon lasts after they arrive at their final destination. By far the greater part of the rubber exported from Para goes to the United States; the European consumption being comparatively very small. Latterly these shoes, in a superior state of finish, have been imported in quantities into England. An extra sole of vulcanized caoutchouc is generally attached to them, the surface of which is so rough as to render walking a little more secure than when the shoes are left without this addition. It has been attempted to imitate these shoes in England by moulding the concrete rubber or caoutchouc into form; but the shoes do not bear contrast with the elegant and light appearance of those of American manufacture. Their valuable properties in resisting damp and cold are best appreciated by those who have used them. They have, however, the somewhat countervailing disadvantage of con-

fining the insensible perspiration of the feet, which leather does not confine. To those who are engaged in pursuits which necessitate exposure to all weathers, night and day, the rubber goloshes prove invaluable.

Caoutchouc—and the remark has an application also to gutta percha—is found, as before observed, exclusively in what botanists term the milk-sap of plants. The milky juice of the lettuce, the spurge, and the celandine, all contain this substance, though in a minute proportion. This juice, or milk, is contained generally in some long, variously curved and branched tubes, not unlike veins, which run in the bark, and also partly in the pith. These have been called vessels of the *latex*. Professor Schulze, of Berlin, struck with the similarity of these vessels to veins, and of the milk to blood, thought they were really analogous in plants to the blood and blood-vessels of man. His treatise was honoured by the Paris Academy with the Monthyon prize. Yet cautious science, says Professor Schleiden, was compelled to demonstrate this theory to be only a brain-spun phantom. The milk-sap is usually of the consistence of thick milk; its colour is usually milk-white,

sometimes it is yellow, red, and rarely blue—more frequently still, it is colourless. Like animal milk, this juice consists of a colourless fluid and small globules. All the varieties contain more or less caoutchouc, which occurs in the form of little globules. These are prevented from coalescing by an albuminous substance, in the same way as are the butter globules in milk. Exactly like the cream in milk, the caoutchouc globules rise to the surface of the milk-sap of plants when left to stand; hence they form a cream, and coalesce, and cannot any more than butter be separated again into their distinct globules. The caoutchouc of commerce is imported under various forms; a very common form is that of the pear-shaped bottles with which every person is familiar. These bottles are produced by spreading layer after layer of caoutchouc upon a pear-shaped mould of unbaked clay. After applying the first layer, the mould is exposed to a column of smoke, and the surface is thus very quickly dried. It is then redipped in the fluid coutchouc, and again dried in the smoke. The effect of this alternate dipping and drying is to produce a laminated structure in the caoutchouc, and if the cut edge of one of these

bottles be examined carefully, it will be seen to consist of a number of layers, and not to form a homogeneous substance; the slight discoloration renders the line of demarcation between each layer in some instances very distinct. When the bottle is considered to be sufficiently thick, it is thrown into water, and in a short time the clay is capable of being entirely removed. It is to be regretted, however, that the Indians have learnt the art of adulteration, and that they are so constantly in the habit of mixing earth with the caoutchouc, managing the deception so well, that it cannot be detected until the bottle is cut into pieces. Frequently, also, small stones are imbedded in the substance of the bottles. To so large an extent is this the case, that, as we have presently to observe, it is necessary to adopt two preliminary processes in the caoutchouc manufacture solely with a view to get rid of these adulterations. The outer layer of these bottles is always black, or deep brown—a colour not necessarily due, as we have so constantly read, to the smoke used in drying, but to some chemical action established by the atmosphere upon the caoutchouc. The interior layers are generally of a

cream colour. Sometimes caoutchouc is imported in the form of large thick tablets. Professor Royle, in directing the attention of commercial men to the East-Indian caoutchouc, and to the form in which the best kind of caoutchouc is received from that country, states that the best price is given for that in the bottle form, or preferably, that which is in the form of a cylinder, from one to two inches in diameter, and four or five inches in length. In all these varieties of form it may be seen by those who have the opportunity of visiting a caoutchouc factory. On such occasions the attention of visitors is often drawn to a trick practised by the Indians. Collecting all the scum and half-dried shreds adhering to the edges of their vessels, they squeeze them tightly together, so as to cause them to cohere, and the mass is then covered over with a layer or two of genuine fluid caoutchouc. In this state it is sold as a solid mass of caoutchouc, which in form it resembles. We have seen such masses cut open, when immediately the fraud became apparent.

A trick of this kind, played upon the author of "Wanderings in South America," is so amusing and characteristic, that we make no apology

for its introduction here. "Some years ago," says Mr. Waterton, "there was a capital trick played me about Indian-rubber. It seems that the wild and uneducated Indian is not without (fraudulent) abilities." Weary and sick our traveller arrived at some Indian huts, which were about ten hours distant from the place where the gum-elastic trees grew. After a little rest he went to them, and with his own hands made a fine ball of pure Indian-rubber; it hardened immediately on its exposure to the air, and was surprisingly elastic. While procuring it, a torrent of rain fell, and so aggravated the traveller's disease, that he was unable to go again to the spot for a second ball. A fine interesting young Indian, observing his eagerness to have another ball, tendered his services, and asked two handsfull of fish-hooks for his trouble. Off he went, and returned in an extremely short period. Bearing in mind the trouble and time it had cost Mr. Waterton to make the ball, the latter could account for the Indian's expeditiousness in no other way, except that being an inhabitant of the forest, he knew how to go about his work in a much shorter way than our 'hor. The ball had very little elasticity in it;

it was tried repeatedly, but never would rebound a yard high. The young Indian watched Mr. Waterton's attempts with great gravity, and when he made him to understand that he expected the ball would have danced better, he called another Indian, who knew a little English, to assure Mr. Waterton that he might be perfectly easy on that score. Mr. W. was given to understand that the ball was like the little moon, which the Indian pointed to, and by the time it grew big and old, the ball would bounce beautifully. This seems to have satisfied our credulous traveller, who gave the Indian the fish-hooks, which the latter received without the smallest change of countenance. Mr. Waterton bounced his ball repeatedly for two months after, but he found that it still remained in its infancy. At last his suspicion was aroused, and he cut the ball in half, and then saw what an artful trick had been practised upon him. It seems the Indian had chewed some leaves into a lump the size of a walnut, and then dipped them in the liquid caoutchouc. It immediately received a coat about as thick as a sixpence. He had then rolled some more leaves

round it, and gave it another coat. He seemed still to have continued this process, till he had made the ball considerably larger than the one which Mr. Waterton had formed with his own hands. In order to put his roguery out of all chance of detection, he made the last and outer coat thicker than a dollar.

CHAPTER III.

PROPERTIES OF CAOUTCHOUC.

RETURNING to the properties of caoutchouc, it may interest some of our readers to learn that liquid caoutchouc has been, at different times, sent into this country. Professor Faraday describes a specimen sent to him as being covered with a pellicle of concrete caoutchouc, supernatant upon a liquid, thick, and of a pale yellow colour, bearing some resemblance to cream. This liquid part retained many of the properties attributed to the fresh sap. The separation appeared to have taken place long before its arrival here. It is considered by Berzelius that the separation of the caoutchouc, existing previously in the form of an oily emulsion in the milk, is due to the coagulation of a portion of vegetable albumen, which gathers out, as it were, the caoutchouc globules into a mass, which floats on the surface. Pure caoutchouc is trans-

parent and colourless. It is perfectly elastic; and when suddenly extended, much latent heat is developed, and free electricity is also given out. It is a bad conductor of heat, and a non-conductor of electricity. When it has once separated from the juice in the solid form, says Liebig, there is no method of obtaining it again suspended as before. In hot water, it swells and becomes soft, but is insoluble both in water and in alcohol. Pure ether dissolves it, and leaves it by evaporation, as already noticed, in a perfectly elastic state. Frederic the Great appears to have been the first to apply this solution to the manufacture of an article of dress. He procured a pair of lasts, in the form of riding-boots, and caused an ethereal solution of caoutchouc to be applied to these lasts, until a coating of caoutchouc of sufficient thickness was deposited on them. The lasts were then removed, and the monarch wore the first pair of riding-boots made from this process, and probably also the last; for ether is too expensive a solvent for caoutchouc, applied to such purposes. When the fresh-cut edges of a plate of caoutchouc are closely applied together, they immediately adhere, he joint is almost as perfect as though no sepa-

ration had taken place. The same effect may be produced by moistening the edges with a little naphtha. Hence the value of caoutchouc to the chemist. He forms an elastic tube of a sheet of it, by simply holding it over a glass rod, and cutting the two edges close off, when, by a little pressure, they unite. In this way he makes almost all the flexible joints of his apparatus, and is entirely enabled to dispense with the costly and cumbrous metallic fittings which would otherwise be necessary. It is certain that, by its adaptation to the wants of philosophy, caoutchouc has contributed, next to glass itself, most valuable assistance to the progress of chemical discovery. Formerly, only the wealthy could afford to make chemical experiments; now, the student, with an expenditure of a few shillings in glass and caoutchouc, has the material for the formation of effective and excellent apparatus.

Caoutchouc is an excellent example of what chemists call *hydrocarbons*. It consists, in fact, when pure, of nothing else but hydrogen and carbon. When caoutchouc is submitted to destructive distillation in a cast-iron still, it yields a very important and curious liquid, which is called

caoutchoucine. This fluid was discovered by Mr. Barnard, in the course of some experiments performed by him at Messrs. Enderby's caoutchouc works at Greenwich. It is prepared in the following manner:—Small lumps of caoutchouc, about two inches square, are thrown into an iron still, connected with a proper refrigerating apparatus. A temperature of about 600° Fahr. is then applied, and a quantity of oils distils over. Nothing but a little dirt and charcoal are left behind in the retort. The oils thus procured are again repeatedly rectified, until at length a most singular fluid is procured. It is the lightest fluid known, yet its vapour is denser than many heavy gases. It is extremely volatile, possesses a peculiar penetrating odour, and consequently can only be retained in well stoppered vessels. Its most remarkable property, however, is, that it is a perfect solvent for the very substance from which it was procured. With this view, it is prepared in very large quantities at the manufactory in question, under protection of a patent. It very readily evaporates, leaving the caoutchouc in its original concrete form upon the surface of any article to which it has been applied. It is largely employed

on this account in the manufacture of various waterproof fabrics, and will doubtless come into most extensive use as soon as the term of the patent expires, as it proves an admirable solvent for many other substances. The residue after distillation is a peculiar greasy substance, which never loses its tenacity and pliability; and it is therefore made use of in the English navy for steeping the cordage, in order to render it more durable. It is said that, in the factory in question, upwards of eight hundredweights of caoutchouc are daily submitted to the process of distillation, for the purpose of procuring the resulting caoutchoucine. The caoutchouc employed for this purpose is the worst kind; the purer sorts being kept for manufacture into various articles.

Caoutchouc, we may remark, before passing on to the consideration of its manufacturing-history, is employed by the Indians, who extract it from the trees, for various purposes. Spread on cloth, they form an impervious fabric, applicable to a number of purposes. Caoutchouc in the solid state is often also employed for making torches. These are from twenty to twenty-four inches long, and about three fingers in thickness. They require no wick,

and burn exceedingly well, emitting a very clear light, but exhaling also an odour which, though far from disagreeable to the natives, is so much so to others as to preclude its use for this purpose by any but the Indians. Torches of this thickness and length will last about twenty-four hours. The formation of squirting bottles out of this substance has already been alluded to. At Para it is customary to form various fantastic ornaments of caoutchouc,—figures of animals, balls, &c. The ornamental devices upon these are produced in the same way as upon the rubber shoes. Caoutchouc is also made into larger bottles, for holding various liquids; a purpose for which it is in every respect well qualified, with the exception of the somewhat disagreeable odour which they communicate to their contents.

CAKES OF CAOUTCHOUC.

The consistence of specimens of caoutchouc seems to differ greatly either with their source or mode of extraction. Some kinds are as hard as gutta percha, and might

serve as a substitute for that substance; but others never become solid, but remain always in a soft semi-fluid viscid state, resembling bird-lime or treacle. At the Great Exhibition some curious specimens were shown, which are represented in the cut, of cakes of caoutchouc said to be found at the root of the India-rubber tree.

CHAPTER IV.

MANUFACTURE.

WE now approach the highly interesting processes connected with the caoutchouc manufacture. It will be useful to consider this shortly under the respective heads, 1, of the manufacture of raw caoutchouc; 2, of elastic fabrics; 3, of waterproof fabrics; and lastly, of vulcanised caoutchouc. If it is added, that the various processes connected with this interesting substance we have personally inspected at the original manufactory in Manchester, an additional degree of interest and value may be felt to attach to the following account of the subject.

Mackintosh's factory stands in a spot a little withdrawn from public notice in Manchester, but surrounded by several of the hundred-voiced cotton-mills whose whirrings fill the air. The first part of the manufacturing process is the purification of the caoutchouc. For this purpose a long

trough is arranged down one side of a large room, which is partly filled with water kept hot by a steam-pipe. Into this trough the caoutchouc is thrown, in the state in which it is received from abroad—in the shape of bottles, or balls, twisted masses, tablets, and skinny shreds. Several persons with large sharp knives cut these masses open, and they are then allowed to soak. By this means all the earthy impurities are softened, and prepared for removal by the next process. A lump of caoutchouc is then taken to a machine which is intended to wash such impurities entirely away. This consists of a pair of powerful cast-steel rollers, the surfaces of which are deeply cut. The caoutchouc is presented to these rollers, which seize it, and grind it with immense force at the same time that a jet of water falls upon the mass, and washes away in a muddy stream all the clay and other foreign ingredients. A curious effect is now produced upon the caoutchouc,—it emerges from the machine in the form of a coarse corrugated band, its particles having been made to cohere by the pressure and heat evolved in the process. The caoutchouc is passed several times through this apparatus, until the water removes

no more impurities; it is then placed aside to dry. It is presumed that now the raw material is sufficiently pure for the commencement of the proper processes of its manufacture. The next step, therefore, is to manipulate the caoutchouc in such a manner as to obtain it in a solid, homogeneous mass. The corrugated bands, which resemble coarse sacking, and are of a yellowish colour, are, when quite dry, taken to a formidable apparatus called the kneading-mill. This is a very massive structure of cast-iron, and as every part is subject to a violent straining, it is rendered as strong as possible. It consists essentially of a hollow cylinder, inside which an iron axis, armed with projecting pieces, revolves horizontally, a certain space being left between it and the sides of the cylinder. About four or five pounds of the purified caoutchouc is stuffed into this iron chest, and the lid is then fastened down by a powerful clamp. Power is then put on, and the central iron axis begins to operate upon the mass of yielding, but tough material placed within its terrible arms. Slowly revolving, it crushes the loose mass by slow degrees into a body of consistent substance, resembling dough. After it has been in

action a little time, an immense amount of heat is developed, so much indeed that the fingers may be as badly burnt as if scalded, although no fuel of any kind is used. The whole apparatus becomes extremely hot. This is due to the extrication of what is called the *latent heat* of the caoutchouc; as it is a fact well known to chemists, that bodies of all kinds have within themselves always a certain charge of caloric, which, not affecting their sensible temperature in ordinary cases, can nevertheless be developed in various ways, and especially by pressure, which seems to squeeze it out.

The caoutchouc is now changed in colour to a light brown, and appears as a glutinous coherent mass. It is extracted from the machine by simply unfastening the lid, when the great hot mass is turned out into the laps of the attendants. This mass is again kneaded in another apparatus, sometimes with the addition of a little dry quick-lime. This process is also attended with the evolution of much heat, and any water yet remaining in the mass is actually converted into steam, a succession of explosions being often heard in the apparatus from the disengaged air and steam. A very large kneading-mill, capable of containing six or seven

masses of the size received by the first, is the last apparatus of this kind in which the caoutchouc is recomposed. After it has been exposed sufficiently long in this engine, the entire mass is turned out as before, and is then placed in a cast-iron mould; it is now subjected either to the action of a powerful screw, driven down upon it so as to compress it into the mould, or to that of an hydraulic press. It is curious that the caoutchouc, in consequence of its elasticity, is better compressed by the screw than the press, a successive action being apparently necessary for this purpose. In this mould the mass remains for some time, until it has taken the shape and size desired; it is then about eighteen inches long, nine inches broad, and five thick.

The last operation to which raw caoutchouc —if such it can now be called—is subjected, is to cut it into plates or sheets, and this is effected by a singular but ingenious machine invented by a Mr. Beale. Every one must have remarked the lined appearance of caoutchouc when sold in the sheet, or in the form of tablets for the purpose of the artist. These lines are so beautifully regular, that they give the caoutchouc sheet very much the appearance of a woven tissue.

All such lines are produced by the knife of the clever apparatus we are about to describe. The cast-iron mould with its block of caoutchouc are placed horizontally upon a movable bed, which the machine causes to traverse backwards and forwards at any desired rate of speed. About the centre of the apparatus a nice and delicate adjustment of mechanism is placed, by which a thin, razor-like knife is made to move from side to side with immense rapidity. To the swiftly-moving edge of this knife the end of the caoutchouc block is exposed; and the whole apparatus having been properly adjusted, the block of caoutchouc is gradually urged forwards against this edge. Instantly a sheet of the substance begins to be separated from it, and by an ingenious arrangement, rolls itself upon a roller above. In this way the mass proceeds until its whole length has been traversed by the knife, when the motion of the bed is reversed, and in its return to where it started, the cutting process begins afresh. By means of screws it is easy to cut the caoutchouc into sheets almost as thin as paper, or into tablets of the thickness commonly employed for erasing the marks of pencils. Just over the edge of the knife

a tiny jet of water plays during the whole time of its operation; this cools the mass, and renders the operation of cutting the caoutchouc very much more easy. With such immense rapidity does the knife of this machine move, that it can scarcely be seen to move at all; and the succession of its alternations is so rapid, that it produces, instead of a rapidly successive sound, a continuous whirring noise, the sure evidence of a high degree of rapidity of movement. With this the first branch of the manufacture of caoutchouc is completed.

Every person is now familiar with the elegant and ingenious tissue in which threads of caoutchouc are confined, so as to render it elastic. This is the fabric of which the springs of gloves, and the elastic part of braces, &c. are made. This tissue is said to have been originally invented by a major in the Austrian service; and very large factories exist in several places in France, which produce nothing else. There are several steps in the process of manufacture which are extremely interesting. In the first place, it is necessary to obtain a thin tape of caoutchouc. In the next, this tape must be cut into delicate threads. These threads re-

quire stretching and winding: they are then woven, and finally, their elasticity, of which they had been deprived, is restored to them. In order to procure the thin caoutchouc tape, a hollow cylinder of this substance, or one of the best bottles imported from Para, is put upon a cylinder of soft wood, of such dimensions as to keep it equally distended. It is then secured to the shaft of a lathe, and exposed to the sharp cutting edge of a circular steel knife, which is kept constantly moistened with water; and its movement being regulated by a screw, it is easy to cut off a spiral length of caoutchouc from the cylinder, of any desired thickness. Another and very ingenious way of effecting the same object is by preparing the caoutchouc in the form of a thick circular cake, which is made fast at its centre to the end of a horizontal shaft, while its circumference is exposed to a circular knife of cast-steel, revolving at the rate of three thousand times a minute. During its revolution, it is constantly moistened by a jet of water, which both cools it and facilitates its action upon the leathery texture of the caoutchouc. In this way, a tape of any length, and of any requisite thickness, may be obtained.

This process is well adapted for the caoutchouc in its recomposed state. The former is more suitable to it in the state in which the best is imported; and it is generally considered that caoutchouc is stronger when employed without having been kneaded than after having been subject to that process. Such caoutchouc, however, must be extremely pure, and, consequently, is more costly than the other kind. Thus the thin tape is procured: this is now to be cut into threads. Some young girls are generally employed to effect this delicate task. Taking a piece of the tape in question, it is drawn through a guide slit against the sharp edge of a rapidly revolving steel disc. In this case, also, its surface is constantly wetted. By this means it is cut into threads, as thin or as thick as may be desired; the slit determining that point. By some apparatus of another kind, the same process is effected without manual assistance, and a number of threads are cut at once. It is a curious fact that these threads, so delicate and elastic, may be easily pieced, if broken, by being obliquely cut, and the pared fresh edges gently pressed together. These threads must now be stretched, and made to lose their elasticity.

This is absolutely necessary, prior to its being woven. It is effected by winding upon power-reels the thread, which is at the same time stretched during its passage through the wet fingers of winding boys. So much heat is extricated, that a stranger, who attempts to hold the thread in the process, gets his fingers severely burnt. It is then left for some days, at the expiration of which all its elasticity seems to have vanished, and it can be treated as common cord. It is now conveyed to the braiding machine. By this apparatus the caoutchouc thread is neatly enveloped in a covering of silk or any other fibrous material. When it leaves this machine the caoutchouc is no longer visible. It is still inelastic, and is preserved in this state until after its manufacture into tissue by means of ribbon-looms. Some beautiful looms of this kind are in operation in the neighbourhood of Holloway. One of these elegant automatic mechanisms will weave in one week five thousand yards of elastic tissue, an inch wide, requiring only the inspection of a woman, who watches, and, if necessary, controls its movements. The process is now complete. But the tissue is inelastic! How is its lost property to be restored?

It appears that, in the loss of its latent heat in the process of stretching, this wonderful property of elasticity was also lost. It is a most curious fact, that by simply warming the tissue its elasticity at once returns; and the fabric is completed simply by passing a warm smoothing-iron over it, upon a piece of blanket. By a most ingenious arrangement, the shrinking which thus takes place has been made to produce a variety of patterns upon the fabric, so as to make it resemble coach-lace. These tissues are valuable for many surgical purposes, and for various articles of dress. The elastic thread is prepared of different sizes: the finest forms ladies' bracelets, and of this, in a pound weight there are five thousand yards. It is also used for cordage, and will bear double the strain of the best sort of hempen cordage, uncombined with caoutchouc. Some of the braiding machines, for the manufacture of these coarser kinds, are quite gigantic.

Let us now see how a mackintosh is made: and first, of the waterproofing solution, or paste. All kinds of coarse and refuse caoutchouc are suitable for making this material. These pieces of caoutchouc are thrown into a cast-iron vessel, which is

fitted with a close lid, and contains a stirring apparatus, moved by mechanical power. The whole arrangements being complete, the lid is secured, and the stirring apparatus is set in motion. By this means, the lumps of caoutchouc, over which a certain quantity of naphtha is poured, are comminuted, and on every side exposed to the action of the solvent. A large amount of latent heat is extricated, and so far favours the solution of the caoutchouc that no external application of heat is required. This goes on for two or three days, at the expiration of which the solution is finished. It is then removed from thence, strained, and worked into a smooth paste by passing between polished rollers. Formerly, it was customary to make the solution very liquid, and to drive off the excess by heat; but at present this waste is not allowed, and only so much naphtha or other solvent is employed as will produce, when finished, a paste of the requisite thickness. If it is necessary to colour the waterproofing paste, a portion of lamp-black or other pigment is mixed with it. The paste is now ready for application to the cloth.

The room in which this process is carried on is a large one, and contains a number of powerful

machines for this purpose. On entering it, the smell of the naphtha used to dissolve the caoutchouc is overpowering. The effect upon the workmen at first is remarkable. We were assured by the manager that frequently the vapour made him feel so thoroughly intoxicated as to render him incapable of walking straight, on emerging into the open air. But the effect is very transient, resembling that of ether or chloroform, when inhaled into the lungs. It did not appear, however, from such inquiries as we were able to make, that any permanent injury was done to the health of the workmen. The cloth employed for mackintoshes is of a peculiar kind, made for such purposes exclusively. It is wound upon a large roller, which supplies it to the machine for applying the paste. The free end of the cloth is passed between two rollers, which spread over its surface, at any degree of thickness required, the layer of caoutchouc paste. A mass of this paste is placed in front of the rollers, on the upper surface of the cloth, as it passes between them. The action of the upper roller, which is of cast-iron, heated, is such, that it spreads the paste the greatest smoothness and accuracy upon

the cloth, which is drawn forward upon an endless web. The cloth, after receiving its layer of paste, continues to be drawn forward, and passes over heated surfaces, which drive off the superfluous solvent from it. Afterwards it is wound up on a drum. It now forms a single fabric, perfectly water and air-proof. Until lately, single fabrics were never used; and the ordinary mackintosh consists of two such layers, which are united into one by being passed between heated rollers: the paste-covered surfaces then adhere together, and the mackintosh, when dried, is complete. The purposes to which the cloth thus made is applicable are innumerable. Silk, alpaca, and other tissues are also waterproofed in the same way.

Of the manufactured and raw India-rubber shown at the Exhibition, the following account has been given in No. 1,233 of the *Athenæum:*—

"It would be impossible for us to enumerate the various inventions of the kind into which caoutchouc enters for this purpose. Class XXVIII. in this Exhibition is devoted to those animal and vegetable substances which are not woven or felted:—and in this is the principal exhibition of Macintosh fabrics. They may be found also in

other parts of the building. There is, however, this peculiarity in the caoutchouc manufactures, that they are almost exclusively English and American. The substance in question seems not to have found its way on to the continent,—and in only a very few of the articles exhibited from the other countries of Europe do we find its value appreciated. The present Exhibition will do much to extend a knowledge of this important substance.

"Of the fabrics which are water-proofed by India-rubber, we may say that they range from the coarsest sack-cloth and canvas to the most delicate linen and cotton cloths. Wherever impermeability to moisture is required, there these fabrics may be employed. America is, as might be expected, rich in India-rubber manufactures. The exhibition of articles manufactured by Mr. Goodyear's patent affords a number of specimens of the various uses to which Macintosh fabrics may be applied. Of these varied uses, some notion may be formed when we say that boots and shoes, air cushions, water cushions, hydrostatic beds, gas bags, blankets, capes, coats, paletots, mud-boots, sponge-baths and bags, buoys and life-

boats, are amongst the articles exhibited. The facility with which bags of this fabric may be distended and emptied has led to the construction of many useful articles. In the American department are some pontoons which were used in the late Mexican war. They are formed of coarse Macintosh cloth; and bags that would serve to reach across a river, and permit the passage of a large army, may be distended with air and filled in the course of a few minutes. They can be again emptied,—and would not then weigh more than could be carried by a good horse.

"These are some of the uses which the soluble and insoluble properties of caoutchouc have rendered possible. This, however, is only a part of its uses.

"India-rubber in its raw state was also exhibited in various parts of the building. In the Indian compartment there are specimens from various parts of Asia. Amongst the American goods will be found some pieces in the rough state. The best exhibition of this kind, however, is that of the Messrs. Bunn & Co., in the North Gallery, Class XXVIII. In their case are specimens of many kinds of native caoutchouc, as well as of the

substance in various stages of its preparation. It has now become an article of very considerable import into this country. From a few pounds annually, it has reached the amount of about 300 tons,—and the quantity is continually on the increase. Although it has lately risen in price, no fear need be entertained of its failure:—as many of the plants from which it is obtained are easily cultivated, and their cultivation is proceeding in several parts of the world at the present moment."

One of the most surprising discoveries of modern times in reference to any manufactured product, is that of the vulcanization, as it is called, of caoutchouc: and this, whether we regard its purely scientific interest, its commercial importance, or the entirely new field of usefulness which it opens up for the employment of this already widely applicable substance. Mr. Thomas Hancock is the inventor of this singular discovery. In spite of the many valuable qualities possessed by ordinary caoutchouc, it had some disadvantages which rendered it inapplicable for many purposes. Its clammy glutinous feel; its hardening by mode- cold almost to the rigidity of wood, and its

susceptibility to decomposition or softening by oils of various kinds, together with its feeble powers of resisting great strains or violence, were all felt seriously to impair its usefulness. The combination of sulphur and other substances with caoutchouc has been found to effect a great change in this substance. In fact, vulcanised caoutchouc is more like a totally new material, than an improvement upon an old one, its whole range of properties is so entirely altered and extended. There are a variety of ways of preparing this new combination of caoutchouc. The original method employed by the patentee is as follows:—A quantity of sulphur is melted in an iron vessel, at a temperature between 240° and 250° Fahr.; into this liquid sulphur the caoutchouc is then immersed, having been previously rolled into rough sheets, or cut to any convenient form or size. There it is allowed to remain until the sulphur has penetrated quite through the caoutchouc, which may be ascertained by cutting a portion of it asunder with a penknife. If the operation is complete, the caoutchouc will be changed throughout to a yellowish colour. The sulphur adhering to the surface is then scraped off, and the caoutchouc will be found

to have taken up a quantity of sulphur from one-sixth to one-tenth of its weight. The caoutchouc is now in a new condition, called vulcanization; it is then dissolved, or made into paste, or in other ways manufactured into various articles. Sulphur may also be made to combine with caoutchouc by reducing it to a fine powder, and mixing it mechanically. It is also possible to make articles formed of unvulcanized caoutchouc absorb sufficient sulphur to effect their vulcanization, by simply rubbing flour of sulphur upon them, after heating them to about 200° Fahr. Vulcanized caoutchouc, prepared in any of these ways, is still soluble; but by carrying on the processes a little further, a remarkable change is effected in it. The caoutchouc plunged in the liquid sulphur is kept in it at a temperature of from 300° to 370°, for a longer or shorter period. Some chemical process seems to be now taking place, and if the immersion is long continued, the caoutchouc becomes of a dark colour, loses its elasticity, and turns nearly black, having the appearance of horn, and may be pared with a knife, similar to that substance. By the effect of high temperature, not carried so far, such a change

in, or modification of the properties of caoutchouc is brought about, that its elastic force is surprisingly increased, and it will now resist to a great extent the action of heat, oil, and grease, as well as the effect of cold, and be now capable of resisting the menstrua by which caoutchouc is commonly dissolved. Three years subsequently to the date of this patent, Mr. Hancock obtained a second, in which he describes several improvements in the manufacture of this extraordinary substance. By means of moulds and rollers he produces various articles of various shapes and forms, which are then vulcanized. Casts from moulds, surfaces for printing, embossed designs of various kinds may all be taken by these new processes, and perpetuated from the articles so formed. Mr. Hancock produces also a tissue which is permeable to air or perspiration. This is effected by punching out holes in it, and then vulcanizing. By means of a peculiar process in the manufacture, vulcanized caoutchouc may be made of a structure as full of air-cells as is a well-baked loaf of bread. This is of value when it is to be applied for the purpose of resisting heavy pressure, as in railway springs.

No change could be more complete than that now effected by any of these processes upon caoutchouc. No longer rigid in cold, no longer soft and ductile by heat, not now affected by its former solvents, and now endowed with more than double its former powers of resistance—truly a great change has been accomplished in it; a change which is not inaptly expressed by the term "conversion." A cannon ball has been broken to pieces by being driven against a mass of it, the caoutchouc only exhibiting a scarcely perceptible rent.

Mr. Brockedon has given the following account of the properties of caoutchouc, in a paper read before the Royal Institution in March, 1851:—

"The effect of vulcanization may be produced by kneading sulphur into caoutchouc by means of powerful rollers; or the common solvents, naphtha and spirit of turpentine, may be charged with a sufficient amount of sulphur in solution to become a compound solvent of rubber. In these cases articles may be made in any required forms before heating for the change of condition. It is necessary, however, for this purpose that the form should be carefully maintained during the exposure

to the heat necessary to effect the vulcanization which leaves it in a normal state. A vulcanized solid sphere of 2½ inches in diameter, when forced between two rollers ¼ inch apart, was found to maintain its form uninjured. In fact, it is the exclusive property of *vulcanized* caoutchouc to be able to retain any form impressed upon it, and to return to that form on the removal of any disturbing force which has been brought to act upon it.

"Caoutchouc slightly expands and contracts in different temperatures; it is also capable of being condensed under pressure. A cube of 2¼ inches, impactly secured, was subjected to a force of 200 tons. The result was a compression amounting to $\frac{1}{10}$;—great heat appeared to have been evolved, and the excessive elasticity of the substance caused a fly-wheel weighing five tons to recoil with an alarming violence."

The evolution of heat from caoutchouc under condensation is a property possessed by it in common with air and the metals. It differs, however, from the latter in being able to exhibit cold by reaction. Mr. Brockedon stated that he had raised the temperature of an ounce of water 2° in about fifteen minutes by collecting the heat evolved by

the extension of caoutchouc thread: he refers this effect to the change in specific gravity. He contends that this heat thus produced is not due to friction; because the same amount of friction is occasioned in the contraction as in the extension of the substance, and the result of this contraction is to reduce the caoutchouc thus acted upon to its original temperature.

CHAPTER V.

APPLICATIONS.

HAVING now completed the history of caoutchouc, we may glance at a few of its applications. We may merely indicate by name its application to the waterproofing of cloth, mentioning in passing, that the new waterproof material now becoming fashionable under various names, and distinguished by it resemblance to a varnished tarpaulin, is a fabric made of cloth, varnished with the solution of caoutchouc; in every respect similar to the mackintosh, excepting that the latter is a double tissue, while this is single, and the surface of caoutchouc is exposed to view. Out of a number of useful purposes to which the sheet caoutchouc is turned, such as gas-bags, elastic tubes, hermetical coverings for bottles, &c., we may mention its application for stopping the necks of bottles as a substitute for corks, as among

the most simple and useful. The so-called caoutchouc corks are in fact pieces of cotton enveloped with a thin layer of caoutchouc.

A singular application of India-rubber cloth on a large scale was noticed in the public journals some time ago. Mr. Hancock had just completed some portable gas-holders for the city of Mexico. As no workmen are to be found in the capital of Montezuma capable of putting an ordinary iron gas-holder together, and as the cost of sending out competent men from this country for such a purpose would have amounted to a large sum, it was suggested that a substitute for iron might be found in canvas rendered impermeable to gas by India-rubber, and Mr. Hancock's experience was called in to aid the carrying out of the suggestion. The vessels made by him were cylindrical bags, twelve feet in diameter, and fifteen feet high, formed of a double thickness of strong canvas stuck together with India-rubber solution. Rings of three-eighths of an inch round iron were introduced in the sides at intervals of about a foot, so as to keep them in their circular shape, and the whole when packed represented a disc of twelve feet in diameter, by a few inches in thickness, in which form they were

intended to be transported to their destination. The cost of each gas-holder complete was about *55l.*, or about 8*d.* for each cubic foot of its contents; a sum considerably less than the cost of a tank and gas-holder of this dimension and of the usual construction, in this country.

Among other applications of caoutchouc, it is stated that an experienced printer of Washington has discovered a method of making printer's ink-rollers of the prepared and improved India-rubber. These rollers are stated to be more permanently elastic, and will last at least ten times as long as rollers made in the usual way and of the ordinary material.

Another singular application of caoutchouc is exhibited in the material called kamptulicon. This is a compound of cork and caoutchouc. In some experiments made at Woolwich the value of this substance as a sheathing for ships of war was well illustrated. On being fired at with a common shot, the material exhibited a scarcely perceptible rent, although the ball had passed completely through it, and in one experiment the elasticity of the material caused the ball to rebound some yards. Its value in retaining iron splinters was

shown afterwards, when it was found that several jagged pieces of iron were firmly imbedded in its substance. The same material has also been used for a lifeboat and for pavement.

Another highly ingenious and successful application of the same material is to be found in what are called the "Patent Epithem" fabrics. This was, we believe, the invention of a surgeon, anxious to find a good substitute for a poultice! Unquestionably the substitute is superior to the thing itself. The epithem is formed of a quantity of pieces of sponge cut into minute shreds, which are attached to a back made of very thin caoutchouc. When used as a poultice the sponge absorbs the water, while the impervious back prevents its evaporation, and thus the artificial poultice is always soft, moist, and warm; three qualities which even the best of Mr. Abernethy's poultices, and he was considered a great authority in such matters, never retain long. The applications of caoutchouc in surgery are very numerous. Vulcanized caoutchouc has a still more extended range of usefulness—its applications being in fact only just in their infancy. By proportioning the degree of its vulcanization,

a material can be procured which is either applicable for locks or other purposes, or the delicate, wonderfully elastic and useful little things now so largely employed under the title of elastic bands. The same substance is also capable of being moulded into a variety of useful forms. For those who have tender feet a moulded sheath for corns is made; for liquids, such as ether, ink, &c., small impervious, insoluble, and hermetically tight bottles are formed. Its use for elastic tubes is infinite; the steam carriage and its tender are united by a tube of this kind, through which the boiler of the former receives its supply of water from the latter. It is also largely employed as water hose for fire-engines; and in the new method of discharging the contents of cesspools. For gas it is also used. A stronger description of the same tube has been used as a substitute for the iron tire of carriage-wheels. Vehicles thus fitted run with great smoothness and without any noise; but the close application of the soft elastic surface of the caoutchouc to the muddy stones, would seem to produce a degree of suction which must interfere with facility of draught. The most important application of this material

is to the formation of springs for railway carriages. Mr. Fuller has patented a certain form of such springs which has been found capable of resisting the most severe pressure. The experiments which have been instituted, have shown that springs made of vulcanized caoutchouc are three times as strong as metallic springs. They have been found capable of resisting, at the height of their tension, a pressure of from five to ten tons. In the reading room of the British Museum, the chairs have all been shod with vulcanized caoutchouc, in order to put an end to the noise created by their being moved about, and the result has proved entirely satisfactory. In the same establishment the doors have been protected with an edge of the same material, by which it is impossible to bang them with any noise. Vulcanized caoutchouc is already taking the place of steel in a number of machines. We recently saw a beautiful automatic cotton mule, made by Mr. Roberts of Manchester, in which several important springs were formed exclusively of this substance. An immense number of minor articles, -h useful in its way, are now made from this ial, and it is evident that a most extensive

series of purposes exists in which it may be usefully applied.

"What the change is," observes the writer in the Athenæum before quoted, "that takes place in the vulcanized caoutchouc, chemists have not yet explained:—probably the sulphuret of a compound radical is formed. Whether this be a correct view or not, the sulphur is retained in the caoutchouc; and one of the great drawbacks in its use in this form is, the smell of sulphur. Many patents have been taken out in this country for processes to prevent this smell; but in all cases sulphur is the agent employed to effect the change, and the smell of it is more or less evident. Goodyear's American process gives less of the smell than any other. India-rubber thus prepared is said to be 'vulcanized,' or 'Thionized.' It is in this form that its most extensive applications as an elastic substance take place. Whenever the object is to prevent the concussion of hard and heavy objects, there India-rubber may be employed. It is used for making the 'buffers' of railway carriages;—and we have observed in the Exhibition a very ingenious instrument, which we would especially recommend to the advocates of Smith-

field market. It is in the form of a 'buffer' to be applied to the tips of the horns of cattle, so that should they happen to butt at the lieges, the India-rubber would so diminish the force as to render the blow rather a friendly act of recognition than a painful rencontre.

"We can do no more here than indicate generally the uses to which this substance is applied, and which the very complete exhibition of the Macintosh Company in the Palace of Glass affords the opportunity of examining in one locality. Bands for letters and packages, strings for bows, driving-bands for machinery, trouser-straps, knee-bands, braces, torsion springs for window blinds and shades, door-springs, sewer valves, air-pump valves, cricket balls, stoppers for decanters, whips, cushions for billiard-tables, and all sorts of elastic webbings, are a few of the applications of the elastic properties of the substance in question.

"In the American department of the Exhibition we see a new application of India-rubber. We have often heard of 'real blessings to mothers;' but what will they say to everlasting toys—toys that will never break? This great desideratum of the nursery has been effected in America by the use

of vulcanized India-rubber. Here we have rattles, lions, tigers, monkeys, horses, frogs, dolls, absolutely indestructible. We fear that this will be considered by the toy-makers of France, Germany, and Switzerland, as one of the evil results of the Exhibition;—for, who would think of purchasing toys of lead, tin, wood, or papier-mâché when they can be had of indestructible India-rubber?

"Another use of the vulcanized caoutchouc is in the formation of sheets, which may be made almost as thin as paper, and which receive impressions with the same facility. These sheets may be printed on, and afterwards formed into a globe by distending with air:—so that a sheet of India-rubber which may be caried in the coat pocket may be extemporized into a terrestrial globe in a few minutes. These sheets are extensively employed for maps, and the great advantage which they have over paper and linen is that they neither tear nor crease. A great variety of specimens of this use of India-rubber are to be found both in the Macintosh Company's case and in that of the American Goodyear.

"We cannot describe the various objects of orna-

ment to which this substance is applied. It may be made to assume any form that the artist can suggest. Embossed sheets, with very elegant patterns, as well as embossed mugs, bottles, &c., are exhibited by the Macintosh Company. In America they have succeeded in making caoutchouc as hard as wood; and chests of drawers, sideboards, rulers, imitations of veneering, and other uses where hardness is required, are amongst the purposes to which it has been applied."

Among the latest applications of the elastic force of caoutchouc, attention was directed by Mr. Brockedon in the lecture before quoted:

1. To Mr. E. Smith's patent application of tubes of vulcanized caoutchouc as *torsion springs* to roller blinds,—adjusted to the heaviest external blinds of houses, or the most delicate carriage blinds; and equally applicable to clocks and various machines as a motive power.

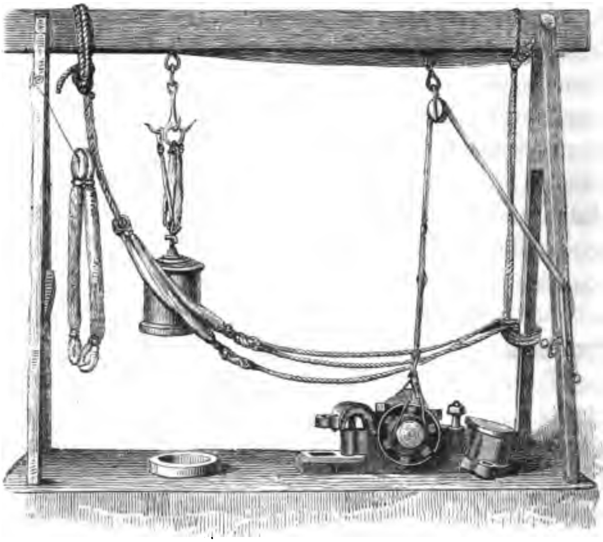
2. To the *raising of weights* (Mr. Hodges' Patent application).—

The history of this invention has been thus given to the writer by Mr. Brockedon. Some woodmen in the employ of the inventor had felled a large log of timber, but found themselves unable

to apply the necessary mechanical force for raising it on to the timber-carriage. A negro, observing the difficulty, hastily collecting a number of ropes, climbed up a tree, and tied one end of several ropes to some large elastic branches. This was done with other trees, and the other ends of the ropes were fastened to the log. One by one the ropes were tightened to their utmost limit, the elastic force of each branch being thus accumulated and made to act on the log; at last a sufficient number of branches were secured, and their collective elasticity at length raised a mass of timber which no combination of levers in their possession was able to accomplish.

Short lengths of caoutchouc (termed by him vulcanized *power purchases*) are successively drawn down from or lifted to a fixed bearing, and attached to any weight which it is required to raise; when a sufficient number of these power-purchases is fixed to the weight, their combined elastic force lifts it from the ground. Thus ten purchases of the elastic strength each of 50 lbs. raise 500 lbs. Each purchase is six inches long, and contains about 1½ oz. of vulcanized caoutchouc. These ten purchases, if stretched to their limit of

elasticity, not of their cohesive strength, will lift 650 lbs. This power—the accumulation of elastic



ILLUSTRATIONS OF THE CUMULATOR OF MR. HODGES.

force—though it obey the common law of mechanical powers, differs enough to be distinguished as a new mechanical power.

The same principle is applicable to relieve boats

in tow from the strain they are subject to, and to easing the strain on ship's cables, especially where several boats are towing one vessel.

The accompanying cut represents the arrangement shown at the Great Exhibition by Mr. Hodges, for the purpose of illustrating his ingenious principles.

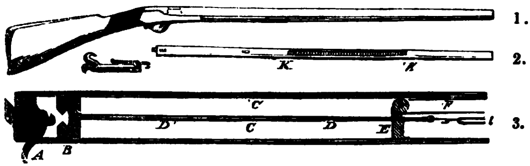
3. Applied as a *projectile force.* A number of power-purchases, attached to the barrel of a gun constructed to project harpoons, will exert a power, if suddenly relieved, proportioned to their aggregate forces.

Similar contrivances have been made for projecting balls 200 yards or more: a charge of No. 4 shot can be thrown 120 yards. On the same principle a bow was contrived in which (reversing the usual form) the string alone was elastic; this bow throws a 30-inch arrow 170 yards.

There were also exhibited adaptations of this material, for restraining furious horses,—for slinging horses whose limbs have been broken,—for enabling bed-ridden persons to assist themselves, —for strengthening feeble joints, and many other new and valuable purposes.

Among other illustrations of the elastic force

of vulcanized caoutchouc which were exhibited in Hyde Park, was what was called by its inventor the India-rubber air-gun, and was described by him in the Catalogue. The novelty of this gun consists in the absence of a reservoir of condensed air, or separate pump, or valve of any kind; the requisite pressure of air for one discharge is instantly obtained from a pull of the trigger, by means of a single stroke of a condensing syringe, which is acted upon by a previously extended India-rubber spring. This gun is represented in the annexed cut.



THE INDIAN-RUBBER GUN.

Flattened bullets, specimens of its effect on an iron target at 20 yards, were also shown.

Fig. 1 represents the gun complete. Fig. 2 is an underneath view of the gun unstocked, showing a slot (K K) in the case, through which are visible the piston-rod and bead, with a portion of the India-rubber hereafter described, and in

the state in which they appear after one discharge, and prior to preparation for another. Fig. 3 represents a longitudinal section of about one half of the breech end of the gun unstocked: A is the trigger; B the piston; C C, the inside of the pump barrel or condensing syringe; D, the piston-rod; E, the pump top, perforated in the centre for the piston-rod to work through, and at the top edge for the reception of the end of the shot barrel, F; G is the bullet, held in its present situation by a slight contraction of that end of the shot barrel. I is one end of the India-rubber spring, attached to the hooked end of the piston-rod, and similarly attached by its other end to a hook in the inside of the muzzle end of the case. The section shows the gun in act of discharge; the trigger being just pulled, releases the piston, which, by the reactive power of the India-rubber spring, rushes to the opposite end of the syringe, condensing the air therein, which air forcibly ejects the bullet.

To prepare the gun for discharge, the ball, if the barrel be a rifled one, must first be rammed down; an adapted hook must then be introduced into the slot (K K), between the bead and the

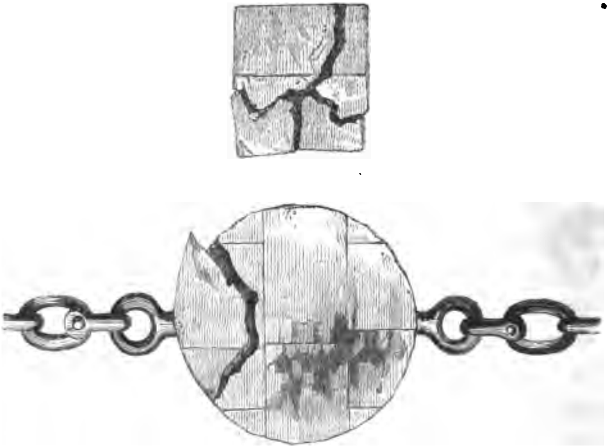
hooked end of the piston-rod. The butt-end of the gun must then be placed against the top part of the thigh, and the hook pulled with both hands, in the direction of the breech, until the trigger, by means of the small spring at its back, catches the piston. With a smooth or unrifled barrel, 400 discharges per hour can be made; the bullet in that case requiring no ramming, it being drawn down the barrel by the partial vacuum caused by drawing down the piston. The spring consists of from sixteen to eighteen India-rubber bands.

Among other applications of Caoutchouc, a very important one has been, the manufacture of a cement, called by its inventor, "Marine Glue." This substance, which appears to be gradually acquiring public value, consists of caoutchouc, gum-lac, and naphtha, mixed together in various proportions, its composition being, however, under the protection of a patent. Its principal value is is expressed in its name, for it is chiefly of use for the timbers of ships and boats. From a pamphlet published by its inventor, we make the following extracts, illustrating the properties of this singular ·pound and its applications:—

"The timbers which compose a ship are exposed to constant strain from the winds, the waves, and other causes, from the time the ship is launched until she is broken up. What then are the qualities required in a substance used to join those timbers? It must be a substance insoluble in water, or it would be useless; it must be impervious to water, so as to prevent leakage; it must be elastic, so as to contract and expand according to the strain on the timber, or the vicissitudes of heat and cold; it should be sufficiently solid to fill up the joint and give strength; and it should be adhesive, so as to connect the timbers firmly together." That these properties are all combined, in an eminent degree, in the marine glue, will appear by a statement of some of the experiments which have been made.

The cut represents several pieces of timber joined together by the marine glue, with a bolt of 1¼ inch in diameter attached to them. The day after the marine glue had been applied, the blocks were tested, by means of the hydraulic machine in Woolwich Dockyard. A strain was applied to the extent of 19 tons, at which point one of the bolts broke, but the junction of

the wood by the glue remained perfect. Two bolts of 1½ inch diameter were inserted on the



BLOCKS SHOWING TENACITY OF MARINE GLUE.

following day into the same block, and the strain was again applied, until it reached 21 tons, when one of the bolts was broken; the junction of the wood still remaining perfect, and apparently not affected.

Numerous experiments have been made to ascer-

tain the best proportions of the mixture constituting the marine glue for various sorts of wood; and in one case, where it was applied to elm, it resisted a strain equal to 368 lbs. on the square inch, when the wood gave way. These blocks were glued, then immersed in water, and on the next day were taken out and tested.

In another experiment, several large pieces of timber were glued together, and suspended to the top of the shears in the dockyard at Woolwich, at a height of about 70 feet above the ground. From that elevation they were precipitated on to the granite pavement below, in order to test the effect of concussion. The wood was shattered and split, but the glue yielded only in a case in which the joint was badly made, and after the third fall. This falling from a height on to a hard substance, is a very severe test of concussion. The explosion of a shell has greater power in rending wood, but does not produce so great an amount of vibration. From the elastic nature of the marine glue, it contracts when the timbers to which it is applied are swollen by water, and expands when the timbers shrink from heat, or any other cause.

A target, constructed with oak and pine balks

of timber, was joined together with marine glue, and fired into with cannon shot; afterwards in its centre a shell was exploded. The result in this case, after the target was almost totally destroyed, proved that the tenacity of the glue exceeded that of the timbers.

To show the facility with which the marine glue might be used in cases of shipwreck or dangers at sea, and in the construction of conveyances for men and ammunition, or other stores, across rivers, when engaged in warfare, a boat was constructed, 12 feet long, 4 feet wide, and 20 inches deep, weighing 2 cwt., and folding up like a fire-screen. The time occupied in unfolding this boat, fixing the hooks and eyes, applying the glue to about 100 feet of seams, launching, rowing with four persons on board to the middle of the river off Woolwich dockyard, and bringing the boat again on shore, was only 35 minutes; without leaking one drop of water. This boat had two air-tight compartments; one in the fore part of 15 cubic feet, and one in the stern of 2½ cubic feet. This boat still remains in the Woolwich dockyard, and may be seen by those interested in the subject.

A cannon ball made of pieces of wood cemented together by this glue has also been made, and fired against a target without being broken, or the joints shaken. A variety of interesting illustrations of the extraordinary tenacity and resistance of the marine glue were shown at the Great Exhibition, and particular attention was claimed by a portion of the mast of the Curaçoa made with this glue, which was torn open by force, the fibres of the wood yielding, and not the seams of union. The marine glue is also very useful for uniting glass together, and the writer has constructed a glass trough of considerable capacity, every join of which is united by this cement, and remains perfectly water-tight. The precautions necessary in uniting it are, to have the glue thoroughly melted, and the surfaces to be united as hot as possible. The joint is then almost inseparable.

PART II.

CHAPTER I.

HISTORY OF GUTTA PERCHA.

Gutta Percha is now awaiting our attention, and it would be scarcely doing justice to this singular and universally useful substance, did we not explain that we have placed it second instead of first simply out of historical justice to caoutchouc; for it appears that this recently-introduced substance already outrivals the former in the extent of the purposes to which it is applicable, and in its excellent properties of adaptation to these purposes. Gutta Percha—pronounced *pertsha*—is, as all are aware, a substance whose history is of only yesterday. And if the Spaniards or the French can boast of having introduced caoutchouc

to European notice, one of our own countrymen has the merit of the introduction of what will ultimately become a far more important substance than it. Dr. W. Montgomery is generally considered to have been the earliest to draw attention to this important product. In a letter addressed by him to the "Mechanic's Magazine" in 1846, the following concise account of its early discovery is contained, and may be requoted with advantage:

"As far back as 1822, when I was on duty at Singapore as assistant-surgeon to the presidency, I had obtained the name of it while making inquiries relative to caoutchouc, of which there are several varieties, and some very fine specimens were brought me, particularly one called 'gutta girek;' and I was told there was another variety called 'gutta percha,' and sometimes 'gutta tuban,' which they said was harder than the 'gutta girek;' but none of it was brought to me at that time, and I lost sight of it, having returned to the Bengal presidency. But being again sent on duty to the Straits settlements, and while at Singapore in
I on one occasion observed in the hands of
an woodman the handle of a parang made
stance which appeared quite new to me.

My curiosity was excited, and on inquiry I found it was made of the gutta percha, and that it could be moulded into any form by simply dipping it into boiling water until it became heated throughout, when it becomes as plastic as clay, and when cold regained unchanged its original hardness and rigidity. I immediately possessed myself of the article, and desired the man to fetch me as much more of it as he could get. On making some experiments with it, I at once discovered that, if procurable in large quantities, it would become extensively useful; and even if only in small quantities, it would still be invaluable in the formation of many surgical instruments which were made of caoutchouc, which had been dissolved in naphtha or other solvents, which became speedily damaged and totally useless in the damp and hot climate of the tropics. I therefore wrote to the Medical Board in Calcutta, strongly recommending its adoption, and sent specimens of the substance. After having examined it, the Board highly approved of my suggestion, and directed me to procure and send some of it to Calcutta, which was done. I also addressed a communication to the secretary of the Society of Arts, London, and sent

some of the substance for investigation and analysis, for which, after my return to England, I had the honour to receive the Society's gold medal. I ascertained that the tree producing it is one of the largest of the forest, growing to the size of three or four feet diameter; that the wood is of no value as timber, but that an edible concrete oil is procurable from the fruit, and often used by the natives with their food."

It appears, however, that a Spaniard, Sir Joze d'Almerida, again contests the honour of first discovery in reference to a substance so closely allied to caoutchouc. This gentleman, having been a long resident at Singapore, came over to England in the beginning of 1843, and brought several samples of the gutta percha with him, some of which he presented to the Royal Asiatic Society, for which he received their letter of acknowledgment and thanks, dated in April in that year. It appears that his attention to the substance had been attracted by noticing the material of which some whips were made. These were brought by some Malays into the town and sold, and so the gutta percha came into his hands. We have no means of stating which of these claims is the most

valid, but would leave them where they lie for others to decide. It is highly amusing to find our neighbours the French also trying to establish a claim to the discovery of gutta percha, which is described in some of their journals as one of the happy results of their expedition to China. At the very period of the despatch of this expedition gutta percha was already patented in England!

The introduction of gutta percha into England is thus described by a writer in the Illustrated London News:—

"It is not quite eight years since the substance called gutta percha was transmitted from Singapore to the secretary to the Society of Arts, for the purpose of subjecting it to a rigid examination, in order to ascertain whether it would be desirable to collect it in large quantities, which were easily obtainable in that island, so that as a new article of commerce it might, with as little delay as possible, be introduced to this country. The samples sent to the Adelphi by Dr. Montgomery, were contained in a small deal box, and consisted, first, of the juice of gutta percha in a bottle; second, thin pieces of the substance, in appearance somewhat resembling leather; third, the gutta

percha in its concrete state; and, lastly, lumps of the gutta percha formed by agglutinating the thin pieces together by means of hot water.

"Chemists, manufacturers, and others were all anxious to obtain small pieces of the material, for the purpose of making experiments therewith. Among these applicants, Mr. Charles Hancock was foremost; and while the chemical committee of the Society were waiting for the reports of practical men on the subject, this enthusiastic gentleman, having had permission to possess a very small piece of the substance, made himself so thoroughly master of the nature of gutta percha, that it was not very long before he took out patents for machinery suitable to the manufacture of articles for various useful purposes to which it has been applied.

"In the meantime, however, the secretary of the Society of Arts had made a variety of experiments with this highly interesting substance; the result of which was, that, at one of their weekly meetings, he was enabled to repeat his experiments before a full meeting, and produced on that occasion a pipe and a lathe-band, and covered a soda-water bottle with a thin coating of the substance.

Impressions of medals which had been produced by the same gentleman were also laid before the meeting."

Two of the staple articles of the gutta percha manufacture, viz. a pipe and a lathe-band, as made by hand, previously to the introduction of machinery for that purpose, were shown in the Great Exhibition. It is an interesting fact, also, that the original specimens sent by Dr. Montgomery to the East India House were likewise exhibited on that occasion, and might have been seen in the Indian collection.

CHAPTER II.

BOTANICAL HISTORY OF GUTTA PERCHA.

The trees which yield it appear widely diffused over the Indian Archipelago; they are common in many places in the island of Singapore, and also in the forests of Johore, at the extremity of the Malayan peninsula. It is also said to be abundant on the south-eastern coast of the island of Borneo. In the forests on the west coast in the vicinity of Sarăwak, Sir James Brooke says, "The tree is called Niato by the Sarăwak people, but they are not acquainted with the properties of its sap; it attains a considerable size, even as large as six feet diameter; is plentiful in Sarăwak, and most probably all over the island of Borneo." It appears also to be abundant in the thousand islands that cluster to the south of the Straits of Singapore. A writer in the Journal of the Indian Archipelago states that it is found all up the Malayan peninsula as far as Parang. In the vicinity of the latter place

it is abundant; yet so ignorant are the inhabitants of the valuable property they have at their own doors, that several mercantile houses, at an early period in the commercial history of gutta percha, sent down to Singapore for supplies of an article that might have been obtained on the spot!

The localities in which the trees delight are the alluvial terraces along the foot of the hills, where they flourish luxuriantly, forming in many spots the principal portion of the jungle. The profusion of vegetation which adorns the Indian Archipelago, and of which the gutta percha tree forms so conspicuous a portion, can scarcely be conceived. The greater part of it is clothed to the water's edge with wood. Passing into the deep shade of its mountain forests, trees of gigantic forms and exuberant foliage rise on every side, each species shooting up its trunk to its utmost measure of development, and striving, as it seems, to escape from the dense crowd; others, as if no room were left for them to grow in the ordinary way, emulate the shape of serpents, compass their less pliant neighbours in their folds, twine their branches into one connected canopy, or hang down, here loose, and swaying in the air or in

festoons from tree to tree, and there stiff and rooted. No sooner has decay diminished the green array of a branch, than its place is supplied by epiphytes, chiefly of the fragrant orchid tribe, of the most singular and beautiful forms.

"The interrupted notes of birds, loud or low, rapid or long-drawn, cheerful or plaintive, and ranging over a greater or less musical compass, are the most pleasing sounds heard; the most constant are those of insects, which sometimes rise into a shrill and deafening clangour; and the most impressive are the prolonged complaining cries of the unkas. As we penetrate deeper into the forest, green and harmless snakes hang like tender branches; others of deeper and mingled colours, but less innocuous, lie coiled up, or, disturbed by the human intruder, assume an angry and dangerous look, but glide out of sight. Insects, in their shapes and hues, imitate leaves, twigs, and flowers. Monkeys of all sizes and colours spring from branch to branch, or in long trains rapidly retreat up the trunks. Deer, and among them the graceful palandoh, no bigger than a hare, and celebrated in Malayan poetry, on our approach fly startled from the pools which they and the wild hog

frequent. Lively squirrels of different species are everywhere met with. Amongst a great variety of other remarkable animals which range the forest, we may, according to our locality, number herds of elephants, the rhinoceros, tigers, the tapir, the bábírúsa, the orang útan, the sloth; and of the winged tribes, the gorgeously beautiful birds of paradise, the loris, the peacock, and the argus pheasant. The margins of rivers and creeks are haunted by large alligators. An endless variety of fragile and richly-coloured shells not only lie empty on the sandy beaches, but are tenanted by pagurian crabs, which in clusters batten upon every morsel of fat seaweed that has been left by the retiring waves. The coasts are fringed by living rocks of beautiful colours, and shaped like trees, flowers, bushes, and other symmetrical forms.

Such is the vivid description of this scene given by a local writer in the Journal of the Indian Archipelago; and amid this exuberance of life the gutta percha lifts its tall head, pre-eminent over many around it.

An interesting account of this tree has been given by Mr. Oxley in the periodical last quoted.

From this account we learn that the tree is from sixty to seventy feet in height, and from two to three feet in diameter on the average. In general appearance it resembles the well-known Doorian; so much so as to strike the most superficial observer. The under surface of the leaf, however, is of a more reddish and decided brown than the doorian, and the shape is somewhat different. Only a short time ago this tree, locally called the tuban tree, was tolerably abundant in the Island of Singapore; but already all the large timber has been felled, and few if any other than small plants are now to be found. The range of its growth, however, appears to be considerable, although as yet the inhabitants scarcely seem to be aware of the fact.

The localities in which it most luxuriantly flourishes are, as already noticed, the alluvial tracts along the foot of the hills, where it flourishes abundantly. But notwithstanding the indigenous character of the tree, its apparent abundance and wide-spread diffusion, it appeared at one time very probable that gutta percha would become speedily a very scarce article, in consequence of the improvident manner in which it was collected by

the Malays and Chinese. The mode of collection then adopted was the following:—A tree of full growth was cut down, and the bark removed in rings, at distances of about 12 to 18 inches apart. An empty receptacle, such as a cocoa-nut shell, the spathe of a palm, or such like, was then placed under the fallen trunk, so as to receive the milky sap which exuded at every incision. The sap was then collected in bamboos, taken to the houses of the collectors and boiled, in order to drive off the watery particles, and to inspissate the liquor to a proper consistence. The process of boiling appears necessary when it is collected in large quantities; but if a gutta percha tree be partially wounded, and a small quantity allowed to exude, and it be collected and moulded in the hand, it will consolidate perfectly in a few minutes, and present the same appearance as that prepared in the other way.

When gutta percha is quite pure, the colour is of a greyish white; but the commercial specimens are more commonly found to possess a reddish hue. This colour arises, it is said, from chips of bark which fall into the sap in the act of making the incisions, and which yield their colour to it.

Besides these accidental chips, there is an enormous amount of intentional adulteration by sawdust and other materials. The quantity yielded by one tree treated in the manner above described, has been stated at from five to twenty catties, so that taking the average of ten catties as obtained from each, and this is a very liberal one, it will require the destruction of ten trees to produce one picul.

"The quantity exported," proceeds the writer, in the Journal of the Malayan Archipelago, from whence we have borrowed the above account, "from Singapore to Great Britain, from January 1, 1845, to June 1847, amounted to 6,918 piculs, to obtain which 69,180 trees must have been sacrificed. How much better would it therefore be to adopt the method of tapping the tree practised by the Burmese in obtaining the caoutchouc from the *Ficus elastica*, (namely, to make oblique incisions in the bark, placing bamboos to receive the sap, which runs out freely,) than to kill the goose in the manner they are at present doing. True, they would not get at first so much from a single tree, but the ultimate gain would be incalculable, particularly as the tree seems to be one

of slow growth, and by no means so rapid as the *Ficus elastica*. We should not be surprised, if the demand increases, and the present method of extermination be persisted in, to find a sudden cessation of the supply."

The discovery of the true botanical position of this important tree is thus given by Sir William Hooper:—"Gutta percha, though only known to Europeans for a few years, is now extensively used in the arts for various purposes. But while thus frequently employed, and constituting an important article of commerce, the plant which produces it was unknown, until, by a lucky accident, during the residence of Mr. Thomas Lobb in Singapore, where he has been (and in other Malay Islands) employed in a Botanical Mission by Mr. Veitch, of Exeter, he detected this plant, and sent home numerous specimens, which prove it to be a new *sapotaceous* plant. Accompanying numerous well-dried specimens, Mr. Lobb judiciously sent small sections of the wood, which is peculiarly soft, fibrous and spongy, pale coloured, and traversed by longitudinal receptacles or reservoirs filled with the gum, forming ebony black lines."

Singapore and Borneo appear to be the only countries at present known from which gutta percha can be obtained in large quantities. The

THE GUTTA PERCHA PLANT.

trunk of the gutta percha tree, (*Isonandra gutta,*) is straight and lofty, and about three feet in diameter at its base; its branches are numerous,

having ascending terminal buds, which are white from exuding gutta; the timber is hard, and sometimes used for building and other purposes. The flowers and leaves are shown in the cut. The proper mode of obtaining the juice is to tap the trees periodically. In the conservatory of Kew Gardens some young trees were planted, under the direction of Sir W. Hooker, the superintendent of that delightful retreat; but from some unexplained cause, the experiment was unsuccessful.

The natural order of plants to which it belongs, Sapotaceæ, consists of trees or shrubs which are chiefly natives of the tropics, and often abound in milky juice. The members of this family are chiefly remarkable for the fruit yielded by them, some kinds of which are held in high estimation. Some yield a thick oil like butter, and some have medicinal properties. But the existence of so remarkable and peculiar a substance as gutta percha in the milky juice appears not to have been noticed until the accidental discovery of the substance in the hands of a native first directed attention to the subject.

Some interesting facts appeared in one of the

public prints in 1850, which deserve extraction here. Previous to 1844, it is observed, the very name of gutta percha was unknown to European commerce. In that year, 2 cwt. of it were shipped experimentally from Singapore. The exportation of gutta percha from that port rose in 1845 to 169 piculs, (the picul is 133⅓ lbs.,) in 1846, to 5,364; in 1847, to 9,296; in the first seven months of 1848, to 6,768 piculs. In the first five years and a half of the trade 21,598 piculs of gutta percha, valued at 274,190 dollars, were shipped at Singapore, the whole of which was sent to England, with the exception of 15 piculs to Mauritius, 470 to the continent of Europe, and 922 to the United States.

But this rapid growth of the new trade conveys only a faint idea of the commotion it created among the native inhabitants of the Indian Archipelago. The jungles of the Johore were the scene of the earliest gatherings, and they were soon ransacked in every direction by parties of Malays and Chinese, while the indigenous population gave themselves up to the search with an unanimity and zeal only to be equalled by that which in the railway world agitated England

about the same time. The Tamungong, with the usual policy of oriental governors, declared the precious gum a government monopoly. He appropriated the greater part of the profits, and still left the Malays enough to stimulate them to pursue their search, and to gain from 100 to 400 per cent. themselves on what they procured from the Aborigines. The Tamungong, not satisfied with buying at his own price all that was collected by private enterprise, sent out numerous parties of from 10 to 100 persons, and employed whole tribes of hereditary serfs in the quest of gutta percha.

This organised body of gum-hunters spread itself over the whole of Johore, peninsular and insular. They crossed the frontier into Ligua, but there the Sultan was not long in discovering the new value that had been conferred on his jungles. He confiscated the greater part of what had been collected by the interlopers, and in emulation of the Tamungong declared gutta percha a royalty.

The knowledge of the article stirring the anxiety of the gatherers, they gradually spread from Singapore northward as far as Penang, south-

ward along the east coast of Sumatra to Java, eastward to Borneo, where it was found at Brune, Sarāwak and Pontianak on the west coast, and at Keti and Pania on the east. The imports of gutta percha into Singapore from January 1 to July 12, 1848, according to their geographical distribution, were:—from the Malay peninsula, 593 piculs; from the Johore Archipelago, 1,269; from Sumatra, 1,066; from Batavia, 19; from Borneo, 55. The price at Singapore was originally 8 dollars per picul; it rose to 24, and fell about the middle of 1848 to 13.

In the course of three and a half years, 270,000 trees were felled in order to get at the gum.

Before concluding the present chapter, it may be interesting to state the fact, that in all probability gutta percha, or some substance closely allied to it, was introduced into England long before our own time, becoming afterwards forgotten. In a catalogue of Tradescant's Museum, (now the Ashmolean Museum at Oxford, but at its first institution, about two centuries ago, at South Lambeth,) we have met with the following sentence. "The plyable mazer wood, being warmed in water, will work to any form." Such

is the well-known and characteristic peculiarity of this substance. Being, however, simply a curiosity, and none dreaming of its practical application, it was soon neglected and afterwards forgotten.

The imports of gutta percha into Great Britain from Singapore are interesting, and illustrate the rapid and enormous development of the trade.

	lbs.
1844	230
1845	22,000
1846	710,000
1847	1,200,000
1848	1,700,000

CHAPTER III.

PROPERTIES OF GUTTA PERCHA.

Gutta Percha is imported into England in a variety of forms, some of which are represented in the annexed engraving. It differs in its state as raw material, very considerably, from the ap-

CURIOUS BLOCKS OF GUTTA PERCHA.

pearance it presents when manufactured. Caoutchouc, on the contrary, presents nearly the same

aspect after as before it has undergone the process of manufacture; its colour is but little altered, and its texture remains the same, except when vulcanized or otherwise modified. But the difference between raw and manufactured gutta percha is so striking, that no person unaware of the fact would be willing to believe them to be the same material. This is principally due to the existence of a vast amount of impurities in the raw material, much greater proportionally than is found in caoutchouc; in the latter, the principal adulteration is of an earthy character, but in gutta percha it is chiefly vegetable fibre, pieces of bark, and earthy matters intermixed.

The appearance of a block of raw gutta percha is very similar to that of a piece of white or dirty yellow wood. It is hard, scarcely indented by the nail, and might be well mistaken for a log of wood from which the bark had been removed. The shape of these

blocks varies, as does also their size and quality. A large number have the form of a thick cake, not

unlike that of linseed after having undergone hydraulic pressure; but others wear a more grotesque aspect, as may be conceived from the figures represented in the cut in the preceding page. The forms of uncouth animals, of monstrous heads, of birds, of lizards, serpents, crocodiles, and such like, are occasionally found among the heaps of the raw material brought to this country. These represent either the idols of the native collection, or are mere vagaries of their imagination. The soft and ductile nature of the material when newly collected, offers a great inducement to those who are disposed to give these curious forms to it.

Gutta percha is very extensively adulterated by the Malays. In collecting it, sufficient care does not appear to be taken, to prevent its becoming impregnated with chips of wood, bark, &c.; and thus unintentional impurities become mixed with it. But there are others of a more serious kind, which

STONE IN BLOCK.

are unquestionably fraudulent. Not unfrequently, in the centre of an apparently excellent specimen of the material, a large stone is discovered, pur-

posely introduced in order to add to its weight; and earth, clay, and wood, are found in different masses. Before the material can be employed, it is necessary to remove all these, and powerful and costly machinery is employed for that purpose. If the material were only collected with sufficient care and by honest persons, several steps in the manufacture might be dispensed with; and had not a simple method of removing these impurities and adulterations been discovered, gutta percha would have ceased to become an object of social or commercial value.

Some of the earliest specimens of gutta percha sent over to this country were placed in the hands of some good analytical chemists, who carefully investigated its chemical composition. Dr. Maclagan appears to have been the first to have analysed it, and the following is the substance of his observations. Gutta percha in its crude state differs in many particulars from common caoutchouc. It is of a pale yellowish, or rather dirty-white colour. It is nearly as hard as wood, though capable of being slightly indented by the nail. It is very tenacious and not at all elastic.

To determine whether or not this substance

really was a variety of caoutchouc, it was submitted to the ordinary process of ultimate analysis, and the following composition per cent. was obtained:—

Carbon	86·36
Hydrogen	12·15
Residue	1·49
	100·00

The residue was considered to be oxygen absorbed from the air during the process employed for purifying it, since the substance, while heating in the vapour bath, acquired a brown colour. The analysis of caoutchouc according to Faraday is:—

Carbon	87·2
Hydrogen	12·8
	100·0

The results of the analysis of gutta percha appeared almost to lead to the conclusion, that it was in reality similar to caoutchouc, the two substances not being generically different.

On destructive distillation, gutta percha was found to yield the same product as common caoutchouc. Both equally yield a clear, yellow, limpid oil, having no fixed boiling point, and therefore being a mixture of different oleaginous principles.

In both substances the distillation proceeds most freely at temperatures between 360° and 390 Fahrenheit. Comparative analyses of similar portions of the two oils were made, and, as is already known of common caoutchouc, the products exhibit a constitution represented by the chemical formula C_{10} H_8, or ten equivalents of carbon united to eight of hydrogen. It was hence considered that gutta percha was really only a modification of caoutchouc.

In its general properties, it likewise shows a similarity to common caoutchouc. It is soluble in coal naphtha, in caoutchouc oil, and in ether. It is insoluble in alcohol, and in water, and floats upon the latter.

Its most remarkable and distinctive peculiarity is the effect of heat upon it. When placed in water at a temperature of 110°, no effect is produced upon it except that it receives the impression of the nail more readily; but when the temperature is raised to 145° or upwards, it gradually becomes so soft and pliant as to be capable of being moulded into any form, or of being rolled into long pieces or flat plates. When in the soft state it assumes all the properties of

common India-rubber, but it does not retain these properties long. It now begins again to grow hard, and in a short time, varying according to the temperature and size of the piece operated upon, it regains all its original hardness and rigidity. A ball one inch in diameter was completely softened by boiling water in ten minutes, and regained its hardness entirely in less than half an hour. It appears capable of undergoing this alternate softening and hardening any number of times without change of quality.

It is also to a certain extent ductile. When soft, it is easily torn across, but when hard, it is very tenacious. A piece not an eighth of an inch in thickness, when cold, easily raised a weight of forty-two pounds, and only broke when half a hundredweight was attached to it.

Mr. Whishaw, in a paper read to the British Association, details the observations of another analyst upon this substance. He states, that contrary to the general opinion that gutta percha is a simple hydro-carbon, it was found to consist of at least two distinct materials, besides a notable proportion of sulphur—viz. 1, a white matter, which was gutta percha in its pure state; 2, a

substance of a dark brown colour. It would also seem to have a compound intimately mixed with it, and to which its cheesy smell is due; which resembles, if it is not analogous to, the caseine of milk. In some specimens of gutta percha this substance appears much more particularly perceptible than in others,—if at least the smell is to be taken as an indication of its greater abundance.

The mode of separating the two substances of which gutta percha consists, namely, the white or pure gutta percha, and the brown pulverulent substance united to it, is exceedingly simple. A dilute solution of gutta percha is made in chloroform or in bi-sulphuret of carbon, and, after a repose of some time, two very different strata are obtainable, the one being the solution of the white or pure gutta percha, while the other consists merely of the brown insoluble matter floating on the denser solution; the white or pure gutta percha is obtained by separation and evaporation; and by repeated washing with the solvent, the pure material is readily separated from the brown substance, which can then be obtained in a pulverurent form.

In the admixture of foreign matter with gutta

percha, the material is very much reduced in strength. Thus, the handles of whips, which have been made of some of these mixtures, have been sent back by the purchasers to some of the manufacturers in the shape of dust. The same may be said of a spurious article *called* gutta percha, used for covering telegraph wires, which, after a short time, was found to be in the same state as the residue of the whip handles. One person took out a patent for an admixture of powdered glass with gutta percha, specimens of which, after exposure to the atmosphere for one month, were found to be wholly disintegrated. The only substances which are found to be beneficially applicable for the purpose of mixing with gutta percha, are caoutchouc, and plumbago, or black-lead; in both cases the admixture of the two substances respectively being only about one-ninth of the weight of gutta percha. Pipes and bands made of gutta percha should not be used for twelve months after being manufactured, as they are found, when in an unseasoned state, to contract to a very great extent. Under the influence of heat and pressure, gutta percha will spread to a considerable extent, and more so if mixed with foreign matters. If we except

plumbago, all the mixtures of gutta percha and other substances are found to increase its power of conducting heat. By heat, gutta percha assumes a darker colour, and the effect of heat on foreign colours mixed with the gutta percha is to give them a deadened appearance. Various experiments have been made in order to ascertain the possibility of uniting colouring matter with this substance, without rendering it brittle or deteriorating its qualities. From these it would seem that the only pigments to be relied on for this purpose are orange lead, rose pink, red lead, vermilion, Dutch pink, yellow ochre, and orange chrome. It may, however, be doubted, whether any of these mixtures are as durable as the original simple substance. The best composition for increasing the pliability of gutta percha, is that formed in conjunction with caoutchouc tar, and next in order, that of its own tar; and the best material at present known for moulding and embodying is obtained by mixing gutta percha with its own tar and lamp black.

A great number of patents have been taken out for the combination of gutta percha with different substances. Thus, it has been used as an ingredient

in mastics and cements. Mr. Hancock unites it with caoutchouc, and another substance called *jintawan*, by which an elastic material results, which is impervious to and insoluble in water. The hardness or elasticity of the compound is easily determined by the alteration of the amount of gutta percha used; the latter being added in greater proportions if firmness is requisite, and the contrary if flexibility and elasticity are desired. From this mixture a very curious substance, light, horny and spongy is prepared, suitable for stuffing or forming the seats of chairs, &c. By an alteration of the process much hardness is acquired, and a material obtained which is capable of being turned in a lathe, and otherwise treated in the same manner as ivory or bone. By mixing a proper proportion of sulphuric acid with it, and adding a portion of wax or tallow, it may be reduced to any degree of solubility in its ordinary solvents, and thus made to furnish a varnish impenetrable to water; such a fluid is applicable for painting in colours, or other purposes.

A curious property of gutta percha was communicated by one of the members of the Royal Scottish Society of Arts at one of its meetings.

When cast and rolled into sheets, it assumes the nature of a fibrous substance, acquiring tenacity in a determinate direction. When in the roll or sheet this tenacity is longitudinal, but if a strip be cut from the breadth, two peculiarities occur; the strip is susceptible of a definite elongation to nearly five times its original length, and its direction of tenacity is reversed. When it is considered that gutta percha is originally a fluid substance, these properties are indeed curious and remarkable.

One of the most interesting properties exhibited by gutta percha is its excellent insulating power for electricity. Dr. Faraday has given an admirable account of this quality, in a letter to the Philosophical Magazine. Its use depends, he observes, upon the high insulating power it possesses, under ordinary conditions, and the manner in which it keeps this power in states of the atmosphere which make the surface of glass a good conductor. All gutta percha is not however equally good as it comes from the manufacturer's hands; but it does not seem difficult to bring it into the best state. A good piece of gutta percha will insulate as well as an equal piece of shell-lac,

whether it be in the form of sheet, rod, or filament; but being tough and flexible when cold, as well as soft when hot, it will serve better than shell-lac in many cases where the brittleness of the latter is an inconvenience. Thus, it makes very good handles for carriers of electricity in experiments in induction, not being liable to fracture; in the form of band or string it makes an excellent insulating suspender; a piece of it in sheet makes a most convenient insulating band for anything placed in it. It forms excellent insulating plugs for the stems of gold-leaf electrometers when they pierce through sheltering tubes, and larger plugs supply good insulating feet for extemporary electrical arrangements. Cylinders of it, half an inch or more in diameter, have great stiffness, and form excellent insulating pillars. In these, and in many other ways, its power as an insulater may be useful.

Because of its insulating powers, it is also an excellent substance for the excitement of negative electricity. It is hardly possible to take one of the soles sold by the shoemakers, out of paper, or into the hand, without exciting it to such a degree as to open the leaves of an electrometer one or

more inches; or if it be unelectrified, the slightest passage over the hand or face, the clothes, or almost any other substance, gives it an electric state. Some of the gutta percha is sold in very thin sheets, resembling in its general appearance oiled silk, and if a strip of this be drawn through the fingers, it is so electric as to adhere to the hand or attract pieces of paper. The appearance is such as to suggest the making a thicker sheet of the substance into a plate electrical machine, for the production of negative electricity.

Then, as to its inductive action through the substance, a sheet of it is soon converted into an excellent electrophorus; or it may be coated and used in place of a Leyden jar; or in any of the many other forms of apparatus dependent on inductive action.

With respect to that gutta percha which is not in good electrical condition, and which constitutes nearly one half of that sold, it has either discharged an electrometer as a piece of paper or wood would do, or it has made it collapse greatly by touching, yet has on its removal been followed by a full opening of the leaves again. The latter effect was traced by Dr. Faraday, and referred to

a conducting portion within the mass, and covered by a thin external nonconducting coat. When a piece which insulates well is cut, the surface exposed has a resinous lustre, and a compact character that is very distinctive; whilst that which conducts has not the same degree of lustre, appears less translucent, and has more the aspect of a turbid solution solidified. Both moist steam heat and water baths are used in its preparation, and the difference of the specimens depends probably upon the manner in which these are applied, and followed by the after process of rolling between hot cylinders. If a portion of that which conducts be warmed in a current of warm air, as over the glass of a low gas flame, and be stretched, doubled up, and kneaded for some time between the fingers, as if with the intention of dissipating the moisture within, it becomes as good an insulator as the best.

Dr. Faraday soaked a good piece in water for an hour; and on taking it out, wiping it, and exposing it to the air for a minute or two, it was found to insulate as well as ever. Another piece was soaked for four days, and then wiped and tried; at first it was found to be lowered in insu-

lating power; but after twelve hours' exposure to air, under common circumstances, it was as good as ever. A week's exposure in a warm air cupboard of a piece that did not insulate, made it much better; a film on the outside became non-conducting, but if two fresh surfaces were exposed by cutting, and these were brought into contact with the electrometer and the finger, the middle portion was still found to conduct.

If gutta percha, either in a good or bad condition (as to electrical service), be submitted to a gradually increasing temperature, at about 350° or 380° Fahrenheit it gives off a considerable portion of water; being then cooled, the substance which remains has the general properties of gutta percha, and insulates well. The original gum, observes Dr. Faraday, is probably complicated, being a mixture of several things; and whether the water has existed in the substance as a hydrate, or is the result of a deeper change of one part or another of the gum, is not at present determined. It would appear to us, at least, that it is merely mechanically mixed with it in the process of manufacture, and the perusal of the stages we shall again have to describe will render the reader

in a position to estimate the probability or otherwise of this opinion.

The electrical properties of gutta percha have been employed in the construction of excellent electrical machines. If a sheet of the very thin gutta percha, of about four or five feet, of superficial area, be laid on a surface, or held against the wall of a room, rubbed with the hand in a silk handkerchief, and then carefully removed by the extreme edges, and held suspended in the air, it will give off a brush-like spark, of several inches in length, to the knob of any conducting surface presented to it. A similar effect may be produced by causing the sheet of gutta percha to be passed once over one, or between two, rubbing surfaces.

An ingenious electrical machine has been constructed of this material, which consists of a frame carrying two wooden rollers, round which, and fitting them very tightly, is made to pass a band of thin sheet gutta percha, about four inches wide. There are two cushions covered with silk, and connected together, so as to press the gutta percha at their upper extremities, and opening towards their lower extremities, at an angle of about 20°. When the handle of the machine is turned,

causing the gutta percha band to pass at a moderate velocity, electricity is given off at about three or four inches below the machines; and if a conductor be applied, the apparatus is qualified to act as a common electrical machine.*

A very singular illustration of the electrical properties of gutta percha was recently given in one of the scientific journals. For a considerable period, the workpeople employed in a thread-mill in Glasgow were seriously annoyed by receiving smart shocks and sparks when approaching or handling the machinery. The construction of this factory is that of a number of flats or floors one above another, laid over with a coating of asphalte, on which the machines are placed, bolted to a sole-plate of iron. The ceilings are supported by a series of iron columns, running down the centre of each floor, and having connexion with the earth, but, owing to the circumstance of the asphaltum floor, in a state of tolerable insulation as regards the machines. The power is derived by drum-shafts running parallel to the wall, and supported on hanging brackets, attached to lateral iron beams in connexion with the columns, motion

* Mr. W. Barlow in Philosophical Magazine.

being communicated by gutta percha belts. Each floor of the factory, therefore, assumes the condition of a vast electrical machine; the lathes representing the prime conductor, and the drums and belts the exciting medium. As may be supposed, under these circumstances, the amount of fluid continuously generated is something considerable, and likely to have caused much discomfort to the workpeople, at a time when their lathes were not in connexion with the earth.

The electricity developed at the shaft and drums was found to be negative, that at the lathes positive. When the current of electricity was connected, so as to flow through a jar of solution into the earth, a feeble, but continuous stream of gas was liberated at the electrometers. The electric current had also the power of inducing continuous magnetism in a bar of soft iron, surrounded with a helix, in the manner of a voltaic magnet.*

The most valuable application of the insulating properties of gutta percha, is that of covering wire for the Submarine Electric Telegraph. The most recent experiment on a great scale of this

* Athenæum, No. 1241.

kind is the telegraph between Ireland and England; and the following account given of the laying down of the gutta percha wire is so interesting as to deserve extraction into our pages. It appeared in *Saunders' Gazette*, which contained an instructive history of the origin and completion of the undertaking:—

"The Howth and Holyhead Submarine Telegraph is now an established fact, and its promoters are well worthy of the earnest congratulations of all who are capable of appreciating the attributes of decision, energy, and skill. It is to Messrs. Newall and Co., of Gateshead-upon-Tyne, assisted by the Gutta Percha Company of London, that Europe and America are indebted for the Howth and Holyhead Submarine Electric Telegraph. Three several companies had been advertised for telegraphing across the Irish Sea; the usual means for alluring shareholders, electing directors, appointing agents, engineers, &c., had all been put into operation. These necessarily ponderous and unwieldy corporations were slowly and laboriously proceeding to put their much-talked-of schemes into practice, when about three weeks ago the idea flashed across the mind of Mr. R. S.

Newall,—'This Irish Telegraph will be a paying concern; it will not require much capital. The firm with which I am connected have facilities for doing the thing; why should not we set about it and do it at once ourselves?' He accordingly explained his view to his partners, got their consent, and immediately applied to Mr. S. Statham, conductor of the Gutta Percha Works, Wharf-road. 'Can you supply us with 80 miles of telegraph wire, doubly covered with gutta percha, within a fortnight?' 'I'll try,' was Mr. Statham's response; and accordingly it was commenced and finished within the time agreed on, being latterly done at the rate of 12 miles a-day. The coated wire was then sent down to Gateshead-on-Tyne to be surrounded with 12 galvanized iron wires, twisted round it in a spiral. The cable being finished, Mr. Newall called on Mr. Statham last Tuesday week, and then for the first time told him the object for which it was manufactured. It was agreed that Mr. Statham should bring a staff of assistants, and the requisite apparatus, to Holyhead the next day to meet the wire. The Admiralty was communicated with, and kindly sent down Captain Beechy, R.N., to give his

valuable advice and assistance; and they also lent the 'Prospero,' Government steamer, Lieutenant Aldridge, R.N., to aid in carrying out the undertaking. Meanwhile the 'Britannia' was hired to bring the cable from Whitehaven, and afterwards pay it out from Holyhead to Dublin. The enormous cable, 80 miles in length, weighing a ton per mile, and all in one continuous piece, was wound up into immense coils, placed on trucks, one after the other, and drawn by steam from Newcastle-on-Tyne to Whitehaven—from one side of England to the other. The 'Britannia,' as has been stated, steamed to Whitehaven to take it on board, when, unfortunately, it was found that the entrance to the dock was too narrow to permit the vessel to enter. The coils had then to be replaced on trucks and carried to Maryport, where they were at length embarked, and speedily conveyed to Holyhead. Now, it might be hoped that all difficulties had been overcome, and that there was nothing to do but to lay down the line; but Mr. Statham, who had already achieved the Dover and Calais connexion, knew too well the dangers and accidents to which those concerned were liable, in the event of a gale, to trust any-

thing to chance, or to proceed one step further without a careful preliminary inspection. The insulation of the copper was tested and found to be defective; then the portions stowed in the various departments of the ship were examined separately, and at last it was ascertained that the fault lay in some eight miles of line lying in the bottom of the hold. There was nothing for it but to disembark the leviathan bulk, and to track it step by step to the exact seat of the defect. This was accordingly done, the fault remedied, and by Tuesday morning the giant rope was in readiness to be placed in its abiding home. Early on Tuesday morning the 'Britannia,' under the command of Captain Browne, and towed by the 'Prospero,' under Lieutenant Aldridge, R.N., commenced paying out the cable, according as it sank by its own weight to the bottom of the sea, along the route from Holyhead to Howth. There were on board, besides the officers and crew, Mr. R. S. Newall, with a gang from the Gateshead Works; Mr. Samuel Statham, with a party from the Gutta Percha Works; Mr. Thomas Allen, the inventor of a new telegraph instrument; and Mr. Reid, jun. Mr. L. D. Gordon (Mr. Newall's partner)

had previously departed to Dublin to supervise the land line from the latter city to Howth. Occasional difficulties were experienced in the paying out of the coils, but they were all overcome through the skill and energy of Messrs. Statham and Newall. Slowly the vessels ploughed on at a rate varying from three to five miles an hour, and at length, between 7 and 8 o'clock on the same evening, the 'Britannia' anchored off Howth. An electric current was sent through the wire to Holyhead, and the returning answer brought the pleasing intelligence that the line was all right throughout, and perfectly insulated. The portion of cable requisite for completing the connexion with the shore and land line was now laid down, and the parties engaged in this arduous undertaking sought some repose, after nearly two days and nights of excessive and harrowing exertion, about daybreak on Wednesday morning. It might be supposed that everything was now smooth and prosperous. Buoyant with hope, those who had already suffered so much in the attempt went down at noon on Wednesday to the Amiens-street terminus, to test the success of their enterprise. The batteries were put in action, the wires were connected, and they anxiously awaited

a reply; but none arrived! They telegraphed to Howth, and were answered—the fault was further off than the land line. An express train was provided, and they dashed down to Howth. Again they telegraphed to Holyhead from the shore—no answer! They took a boat and rowed to the ship. A message sent to Holyhead brought back the reply that all was right there. It was now manifest that the fault lay somewhere between the 'Britannia' and the shore. It was necessary again to take up this portion of the line and test it little by little. The defect was probably caused by the straining of the ship upon a line comparatively short. When discovered, it was soon remedied on board. It was again recoiled into an open boat, the crew of which made a renewed attempt to lay it down to the shore. In the meantime Messrs. Statham and Newall proceeded to shore in another boat with the instruments, but when they overtook the boat which had been engaged in paying out the cable, they found it at a stand, the crew having managed to sink the whole line while still some distance from the shore. Again Mr. Statham had to return to the ship, get another mile of cable uncoiled, recoil it in the boat, and then row to where the deficient extremity of the

cable remained; and there, in an open boat, at 2 o'clock in the morning, with the aid of a little burning spirits, to solder the wires, reunite the gutta percha, and restore the cable to a continuous and insulated whole. This was effected, the remaining distance to the shore laid down, and that night of toil was at length repaid by a success the most ample and complete. On Thursday the 'Britannia' let go the cable and steamed away; while those on shore, after repeated experiments, were satisfactorily convinced that the communication with Holyhead was now at length without impediment."

The process of manufacture of this wire will be described in the next chapter. It appears at first sight difficult to understand how a copper wire can be so evenly imbedded in the centre of a rod of gutta percha, as to be completely insulated even at the bottom of the sea; but this apparent difficulty will vanish as the various steps of the manufacture are detailed. Having now given an account of the chemical, physical, and electrical properties of this substance, we shall proceed to discuss the processes involved in its manufacture.

CHAPTER IV.

MANUFACTURING PROCESSES.

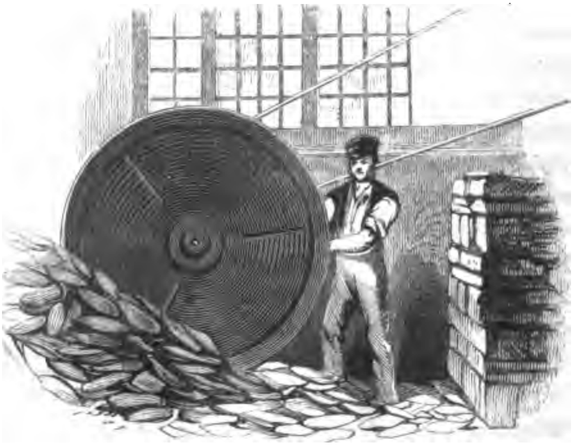
It may be as well to state in the outset of this chapter, that the processes about to be described are those which are carried on at the Gutta Percha Works, near the City Road, London, and that the writer has not visited other factories in which gutta percha is prepared. As those in question are the oldest and most extensive, the processes there carried on may be safely taken to represent the most improved methods of dealing with this substance as yet discovered.

The manufacture of gutta percha is, in reality, a very simple process in its essential features, as may be readily understood by those who will pay attention to the description of the various stages in the following pages. It may be divided into two parts; the first including the preparation of the material, and the second, its application to various purposes.

It has been already stated that gutta percha, as imported into this country, is unfit for immediate use, and requires purification. The first stage of its manufacture is, consequently, that of removing its impurities and adulterations, and obtaining a pure material for further operations. A large store of gutta percha, in blocks, is always kept at these works, out of which, from time to time, weighed portions are removed for manufacture. The blocks are brought into a part of the building where they are to undergo the first operation, which is one of slicing. This is effected in a very different manner from that of caoutchouc, the soft and comparatively pure state of which admits of its being cut with an ordinary knife. Gutta percha, in the block, is nearly as hard as wood, and is, from its partially gummy or resinous nature, much more difficult to cut in the ordinary manner.

The annexed engraving represents the machine employed in this process. It is a powerful circular wheel, armed with knives. The body of this formidable slicer is made of cast-iron, the rim being very thick, in order to give it the momentum of a heavy fly-wheel, which is rendered absolutely necessary by the great resistance offered to the

action of the knives by the material operated upon. This wheel is mounted upon a horizontal axis, on the furthest end of which is placed a pulley, through which, by a gutta percha band led from the driving



SLICING MACHINE.

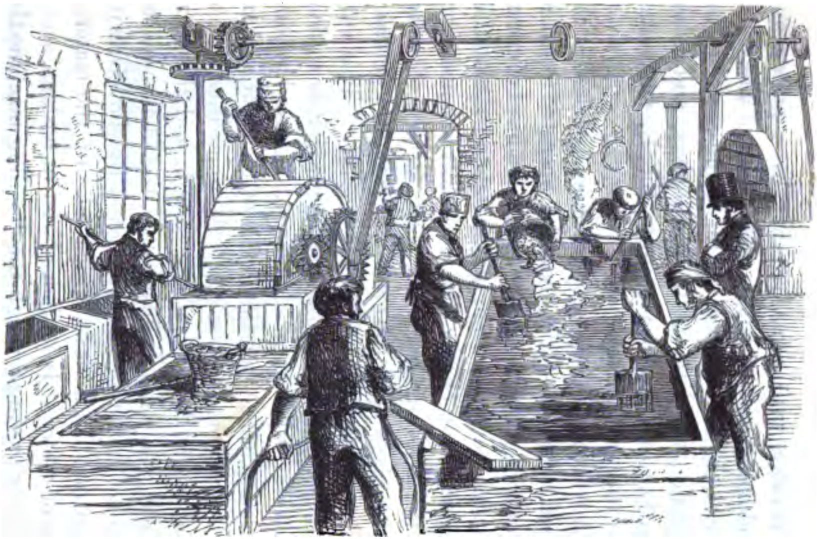
shaft, motion is communicated to the machine. The knives are arranged on the other side of the wheel to that shown in the cut. They are three in number, and resemble broad chisels in their shape. They are set in the frame of the wheel at a particular angle, like the cutter of an ordinary

plane, so as to throw out the slices of gutta percha on the opposite side to that on which it is presented to their action.

The block of gutta percha is placed on an iron shelf, which is so inclined down as to bring the block, by its own weight, under the edge of the knives as they successively present themselves. It is therefore merely necessary to place the block on this shelf, and the machine feeds itself, until the whole piece is cut up. The wheel being set in rapid motion by the strap, the knives quickly reduce the largest-sized mass to a heap of thin slices, resembling as closely as possible large chips of wood. This machine is not altogether without danger, some of the slices flying off with such force as to inflict a very serious blow. One of these pieces is shown in the cut. The knives are also repeatedly injured by the masses of clay and stones which they encounter in the substance of the blocks. They are, however, so secured in the wheel as to admit of being readily removed for the purpose of repair or renewal.

The gutta percha is still in too solid a condition to admit of being at once taken to the cleansing machine. The woody fibre it contains is so held together by the gum as to offer a very intractable mass to any arrangement intended to tear it into shreds, and thus get rid of its impurities. In order to soften it, and thus fit it for further manipulation, it is taken into a part of the factory which is always clouded with steam, and full of noise and clatter. This is shown in the cut. The slices are here placed into large wooden chests, filled with water heated by steam. Here they are left, until by the combined effects of heat and moisture the mass becomes thoroughly softened and fit for the next process.

The next machine we have to describe is called a "devilling engine." Its principle is by no means new, since in various other arts similar means of minutely dividing and tearing a material into shreds are adopted. The tearing machine is placed over and at one end of a long trough, full of warm water. The gutta percha is removed from the wooden tanks in baskets, and supplied to the machine from the top. In the interior of this machine are toothed iron cylinders, which are made



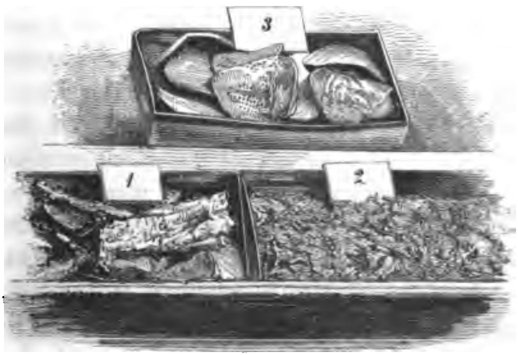
THE "DEVILLING" ENGINE, &c.

to revolve with great rapidity by a pulley and band connected with the main shaft. The gutta percha, in its softened state, is presented to the operation of these toothed cylinders, and is instantly torn into very minute shreds, which fall into the water below.

Advantage is here very ingeniously taken of the great lightness of the material operated upon as compared with its adulterations. It has been seen that in the preparation of caoutchouc the adulterations, being chiefly clay, are easily washed away in the crushing machine, by a stream of water which plays upon the mass. With gutta percha a different arrangement was necessary. This substance has such a low specific gravity as to float on water with great buoyancy. It so happens, therefore, that when the shreds of torn material are thrown upon the water, all the impurities sink at once to the bottom of the trough, and the gutta percha alone is left floating on the surface of the water. It is now easily removed by shovels, with a bottom like a sieve, which take up the material free of water. It is then placed in baskets.

After passing through the devilling machine the gutta percha is nearly, but not quite pure. It has

now also altered in colour, and has a slight rosy or pinkish hue, of which its brownish red colour, subsequently assumed, is an exaggerated representation. It appears in the form of a spongy mass, not unlike the clippings of some animal substance, such as leather, only more crisp and elastic to the feel. In order thoroughly to remove any adhering impurity, it is passed once or twice through an abundance of cold water, and is then taken out and dried in baskets. As yet the sub-



stance has little the character of a gum, and presents a striking contrast to the brown, soft, tenacious mass we next meet with. The cut

shows gutta percha in three stages:—1st. as raw material; 2d. as cleansed and divided; 3d. as rolled into cakes.

When the material is dried and thoroughly cleansed, it is taken to iron chests, the sides of which are double, in order to admit of their being heated by steam. Here it leaves its crisp character, and becomes a soft but incoherent mass. In order to render it tenacious and consistent, and thus fit for the manufacture of various objects, it has next to be subjected to the operation of the masticating machines.

Several rows of masticating machines are arranged horizontally on the floor-level. They resemble, in some respects, those used for the manufacture of caoutchouc. Each machine is heated by steam, and consists of a cast-iron cylinder, with a movable lid, and a central masticator, in the form of a solid axis of iron, which is made slowly to revolve. A quantity of the softened gutta percha is taken by the workmen, and the lid of the masticating engine being removed, the material is forced into it. The lid is then fastened down by an iron bar, the masticator is made to revolve, and steam is turned on to the cylinder.

Under the combined effects of pressure and heat, the mass soon begins to assume a consistent character. The slow but powerful revolutions of the central masticator compress it so violently against the sides of the cylinder as thoroughly to incorporate it; and in a few hours the same material which we saw in the form of shreds, appears as a soft, sticky substance, easily moulded into any form, and hardening in that shape so soon as it becomes cold. The steam is turned on to the masticating machine for about an hour at first, and the mass retains sufficient heat not to require its further use until the process is completed. By removing a small piece of the material as it presents itself at the round hole at the summit of the masticating cylinder, and carefully examining its condition, it is possible to ascertain the right time necessary for this part of the manufacture. The gutta percha is now of a brownish-red colour, a physical change which is the obvious result of the heat, steam, and pressure to which it has been subjected. It is, in fact, not improbable that a slight chemical change has taken place in the material, to which its altered colour may be partly attributable. It appears tolerably certain that a large amount of water is

incorporated into the mass in the prolonged kneading process where steam is so abundantly diffused through the cylinder.

In this warm state gutta percha is used for all ordinary purposes. But it is sometimes desirable to colour it; and in order to do so it has to undergo a second mastication. The substances which are capable of being mixed with gutta percha, without injury to its tenacity, have been already mentioned. Some of these increase its density and hardness, and thus fit it for such purposes as the rollers in flax machinery, or the teeth of cog-wheels. But others are merely intended to give variety of colour to the material. Whatever be the colouring substance, it is intimately mixed with the gutta percha in the masticating machines, being put into them in the form of powder, to which a mass of pure and soft gutta percha is added;—the whole then becomes blended together. As this is not generally required to be done on a very large scale—the coloured material being chiefly used for ornamental purposes—small masticating engines are arranged near the larger ones, in which the materials are placed. The construction of these

does not differ from that of the larger machines. They have the central axis, slowly revolving, the supply of steam, heat, the hinged door, &c., and in every respect resemble the larger ones except in size.

Thus far we have traced gutta percha in its progress from the state in which it is imported, to that condition in which it is fitted for every variety of manufacturing use to which it is subjected. The contrast is very remarkable in the physical condition of the material before and after having undergone these processes of manufacture. From a fibrous yellowish substance, it has become converted into a brownish wax-like mass.

From the masticating machines the material is taken to the various parts of the works, in which it is wrought into form; and to these we shall successively pursue it, commencing with the most simple process, which is its conversion into flat sheets by the rolling mill.

For convenience, the rolling mill is placed as near the masticators as possible, in order that the material, while yet soft and hot, may be brought to it in that condition. The masticatory process being completed, the bar of iron which bolts down

the door confining the material to the narrow cavity of the machine, is struck aside, and by a curious movement the whole mass of gutta percha rises up in one lump out of the cylinder, and is caught and removed by two men. It is taken at once to the bed of the rolling machine, where it is somewhat moulded, and then presented to the action of the engine.

The rolling machine is a very simple piece of mechanism, and closely resembles that employed in rolling metals. It is represented in the cut. It consists essentially of the following portions:—The gutta percha being spread out on the bed in front of the machine, is pushed forwards by the attendants until it is seized between two steel rollers which slowly revolve. In passing through the rollers, the soft material is spread out into a flat sheet, the thickness of which is determined by the distance of the rollers from each other. This sheet, on emerging from the rollers, is received on a broad endless band of felt, which is carried onward at the same rate as the revolution of the rollers discharges the gutta percha in sheet. Although, therefore, it emerges from the rollers in a soft and sticky state, its flatness is not affected, as it

THE ROLLING MILL.

would be if the band moved too slowly, and its thickness remains unaltered, which would not be the case if it moved at a faster rate than that at which the sheet was formed. This band runs on rollers placed at proper intervals, and extending the whole length of the building. In order to cool the heated sheet of gutta percha, a fan, driven by machinery, blows down upon its surface a powerful current of cold air, so that by the time the sheet returns to the front of the machine it is nearly cold. When one length has been rolled out, the machine is thrown out of work, and the gutta percha is allowed to cool.

It does not appear that one rolling is sufficient —the surface of the sheet remaining rough and full of air-cells. A second or third rolling is consequently adopted; the size of the sheet being thus extended, while its breadth is increased, and its thickness diminished. The repeated rolling appears to condense the structure of the gutta percha, and to give it considerable hardness. The rollers are capable of adjustment to any required degree of thickness or tenacity. This is effected by screws which elevate or depress them, and thus increase or diminish the distance at which

they revolve from each other. It is not generally necessary to make gutta percha sheet very thick. By repeated rollings in these machines, and diminishing the distance apart of the rollers, the sheet is reduced almost to the thinness of tissue paper; and in this form presents a beautiful aspect, not unsimilar to that of shot silk. In this state it is useful for surgical and other purposes. The fabric is, however, very easily torn, and its value is consequently limited.

One of the most important of the variable uses to which gutta percha in the sheet is applied, is for making driving-bands for machinery. The manner in which these are cut from the sheet is both simple and ingenious. At the furthest end of the rolling-machine is a large wooden drum, on to which the sheet of gutta percha, when sufficiently cold, is wound. At a little distance from this is another drum of a similar kind; and in the interval between the two is a metal frame, with a number of vertical slits in it, set closely together. Into these slits, at any required distance apart, sharp knife-blades are slipped; and these, as the sheet passes from one drum to the other, divide it with great smoothness into the

various widths employed; these are afterwards unwound from the second drum and coiled up. When these ribbons of gutta percha are required for driving-bands for machinery, they are passed through a simple little machine, which makes them of a uniform width, and hardens them, rounding also the edges, and thus obviating their wear by friction.

Leaving now the lower portion of the building, and entering a series of rooms up-stairs, the variety of applications to which gutta percha has been put is strikingly impressed on the visitor by the numerous groups of artisans, all occupied in different ways on this ductile and plastic substance. Of late, gutta percha has been very extensively used for ornamental objects, such as ink-stands, pen-trays, baskets, watch-stands, vases, &c.; and its durability over porcelain, or even wood, for these and similar objects, renders its extensive use in such cases easily appreciable. The manufacture of these objects occupies a large number of clever modellers and stampers. The original design having been selected, a model is prepared, from which an electrotype cast is taken and converted into a mould. The cast is made

solid at the back by being "backed up" with lead, and is thus fitted to bear the pressure requisite for driving the gutta percha in its soft state into every part of the mould. The two pieces of the mould being accurately fitted to each other, a heated mass of soft gutta percha is placed between them, and the mould being closed, is then subjected to the pressure of a powerful screw. Every crevice of the mould is thus entirely occupied with the material. When cold, the mould is removed and opened, the gutta percha taken out and trimmed, and then appears of the perfect form of the original model.

In this simple manner all the more ornamental articles are produced. The manner in which colour has been imparted to them has been already partly described. A very pleasing imitation of old oak is made by mixing together, on a heated slab in the moulder's room, gutta percha of a light yellow, with the same material of a dark brown colour, not to the extent of complete incorporation, but to such a degree as to leave the streaks of the different materials visible in the mass. The appearance of marbling is given in the same manner.

When the gutta percha leaves the mould, its surface, although smooth, does not possess that degree of lustrous polish which it is thought necessary to give to ornamental objects. This is effected by the application of a varnish, composed of gutta percha and other materials, and the brilliancy of which is very extraordinary, and also very enduring. Some of the objects almost resemble glass, so lustrous is their surface.

While many articles thus admit of easy and rapid production by the process of moulding,

GUTTA PERCHA ORNAMENTS.

others require that of modelling, and many, a combination of both of these departments of practical art. Some of these are shown in the

cut. In order to give every facility for this, and for the union of different parts of objects together, steam-pipes enter into every room, supplying heat to slabs of marble or metal, or troughs of water, and thus affording a constant means of softening, or rendering ductile, pliant, or adhesive, the material operated upon. An enormous amount of steam is consumed in these and in the masticating rooms, for the supply of which, capacious steam-boilers with large steam-chests above them are continually kept heated. The readiness with which the material in its soft state obeys the will of the modeller is well illustrated in these rooms in the variety of forms it assumes under his manipulation, some for ornament, and some for use.

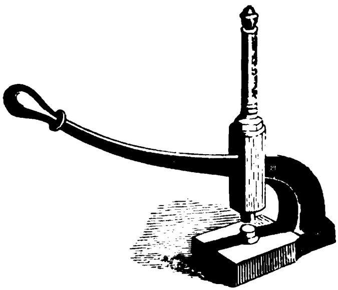
The manufacture of gutta percha string somewhat differs from that of other objects. A sheet of thick gutta is subjected to the pressure of a steel roller of a flat description, on the surface of which are a number of parallel knife-like edges. The sheet is thus nearly cut through into a number of strips; one by one these are torn off, and are placed in warm water, by which they become sufficiently softened to admit of extension. An attendant

then begins to draw out the end, throwing it as he does so into another trough of warm water, and continues pulling out and extending it in succession through the whole length. This is then repeated back again into the original trough, and so on, until the string is reduced to the required size. Gutta percha string is useful for many minor purposes, and particularly for the lines of window-blinds ; but it is a little too unyielding for many others to which it might be applicable. Its tenacity is considerable, but not nearly equal to that of hemp string of the same thickness.

Sheet gutta percha is cut into soles for boots and shoes by the simple but ingenious machine shown in the cut. This machine is a modification of the paper-cutting engine patented by Mr. Wilson. A piece of gutta percha of appropriate width is selected and cut into the required lengths, (six or eight pieces being operated on at once,) by the descent of a sharp blade, impelled by a powerful mechanical arrangement set in motion by a pulley and band. Another machine acts on these pieces and cuts them out into the form of a half sole, by six or eight at a time. This is done with great rapidity, an attendant on one side sup-

THE SOLE-CUTTING MACHINE.

plying the machine with material, and one on the other removing the pieces as fast as they are cut out. In order to give these the stamp of certification of their origin, the little instrument shown in the cut is employed, and by depressing the handle, the words "Gutta Percha Company" are marked upon the material, in the ordinary way of embossing.



EMBOSSING PRESS.

The manufacture of gutta percha tubing presents a degree of apparent complexity which the other departments passed through certainly have not. Both it and the wire covered with gutta percha are prepared in a building detached from the rest, and into which few persons are generally permitted to have entrance. In reality, however, the tube-making machine is only a new applica-

tion of a very old contrivance for the production of tubes from soft substances. The Italian macaroni is made, in all essential particulars, on the same principles as gutta percha tube. The adaptation of the machine to the specific wants of the gutta is, however, ingenious, and its working is very efficient. It is, perhaps, difficult to convey a clear idea of this mechanism to a reader without the assistance of an engraving, which we have been unable to obtain, but we shall make the attempt in the following manner:—

When a soft tenacious substance is forcibly pressed through a metal tube, it issues from it in the form of a cylinder, which, if sufficiently adhesive, it retains; but if within this tube a rod of metal were fixed in such a manner as to leave an interval between it and the internal wall of the tube, then it is evident that, in forcing any soft material through it, it would emerge as a hollow tube, the hollow being the result of the obstacle offered by the solid rod inside the cylinder. Upon this principle the gutta percha tube-machine is made.

It consists essentially of the following portions;—a cylinder, to hold the softened material;

a moulding-piece, to govern the size of the tube; and a trough of cold water, into which the tube is drawn. The cylinder, which acts as a reservoir for the material, is a strong cast-iron tube, heated by steam, and furnished with a mechanical arrangement by which its contents are urged forwards and presented to the hole through which the tube issues. On the cylinder being charged with a mass of soft gutta percha, the tube-drawing commences. A portion within the cylinder forces out at its opposite extremity a mass of gutta percha in a soft state, but tubular. This is gently drawn forwards into a long trough of cold water, which enters the tube, and thus prevents its collapse, and promotes its rapid consolidation. The tube, passing onwards, is drawn forward by hand, and the rapidity or slowness with which this is managed depends entirely upon the dexterity of the tube-maker; if he drew too fast, the tube would be too much thinned, and if too slow, it would be very irregular in size. The secret appears to lie in an adaptation of the speed to that of the emergence of the material. So successfully is this manufacture conducted, that a tube of this material has been made in one length

of 500 feet, a circumstance altogether unknown in the manufacture of metal tubes. In order to diversify the size of the tube, it is merely necessary to alter the metal opening of the cylinder, and to substitute another with an aperture of a different size.

If our account of the tube-making machine has been clearly understood, the following description of that by which the electric telegraph wires are covered will not be difficult of comprehension. The machine, in many respects, is analogous to that used for the tubes. There are, however, two cylinders, so that when the one has discharged its contents, the other may be brought into operation so as to cause no interruption to the process. At the aperture where the gutta percha is forced out of the machine, the wire appears, being led through its centre. The machine being put in motion, the wire is drawn gradually through this aperture, and as it passes through a mass of hot gutta percha, becomes coated with it to whatever thickness the opening admits of. As it passes, it is drawn into cold water, and coiled on a drum, as before, by the attendant. There are many ingenious arrangements about this machine which it is unnecessary

minutely to describe. Its efficiency is remarkable; and the thousands of miles of wire which have passed through it are already a considerable number. The wire is very evenly coated, and on a section of it the copper is seen to be very generally in the exact centre of the piece.

Gutta percha covered wire was originally made by a different method, and this process is still that which is commonly described. Several wires are laid parallel, a strip of gutta percha being placed below, and another above them; the whole is then passed between a pair of polished grooved rollers; the pressure binds the gutta percha firmly to the wires, while the edges between the grooves indent the gutta percha so deeply that it may be easily separated into wires, each one containing its own core of copper. This plan is a more rapid method, but it does not seem probable that it can be so complete and successful as the preceding one.

The only remaining manufacture which we have become personally acquainted with, is that of gutta percha solution. For this purpose a row of vertical cylinders are placed against a wall, fitted with an agitator, and capable of being -med. Into these cylinders a quantity of gutta

percha is put, with a proper proportion of coal naphtha. They are then kept in agitation until the solution is completed, when it is withdrawn, poured into cans, and a fresh charge is put in. The principal uses of the solution are for general waterproofing purposes, and also for securing the joints of articles made of gutta percha so as to complete their union. It is also largely used for the application of boot and shoe soles.

We have thus described all the more important parts of this manufacture, and the information here given, being the result of a careful and repeated examination into the processes actually carried on at the works in question, may be regarded as on that account interesting and valuable, since it is not to be found in detail in any works hitherto published. We have not attempted to describe those parts of gutta percha manufacture in which this substance is mixed up with others, and treated in various ways, because they have not fallen under our notice; nor do they appear as yet to have assumed much commercial importance. Considering that the whole manufacture is one of entirely recent development, and that in a few months after the material was known

in England the whole of the processes we have described were begun to be practised, it must be admitted that, next to the wonderful properties of the material itself, our admiration must be excited most strongly by the ingenuity and talent which has developed the steps of its manufacture.

CHAPTER V.

APPLICATIONS.

Such an extensive series of applications of gutta percha already exists, that it is somewhat difficult to make a right selection. We shall endeavour to do so out of the various papers and pamphlets on this subject which have been issued by the manufacturers. And we may commence with those of gutta percha tubing—probably the most extensively applicable article yet made of this material.

The properties of this tubing are expressed in the following terms:—

"This tubing is alkali and acid-proof, being affected only by the strongest oil of vitriol and nitric acid. The most concentrated acetic, hydrofluoric, and muriatic acid, and chlorine, have no injurious effect upon it; it is also unaffected by any of the cold fixed oils, &c. It is totally impervious to

wet, and may be steeped in water or buried in damp or marshy ground, without injury. It is unaffected by salt water, and therefore valuable on shipboard. It is easily repaired. In case of any stoppage, an incision can be made in the tubing with a sharp knife, and readily closed again by means of a warm iron.

"Amongst the peculiar properties possessed by this tubing, are the following:—

"Lightness, combined with remarkable strength (the ¾-inch tubes having resisted a pressure of 337 lbs. on the square inch without bursting).

"It is not affected by the carbonic acid, or fixed air in water (so injurious to health in the use of leaden pipes), acetic, hydrofluoric, or muriatic acids, alkalies, grease, &c. This remarkable property renders gutta percha valuable for the conveyance of water, lining of cisterns, &c., as it preserves the water in its natural purity, uncontaminated by the mineral poisons destructive to health, which result from the use of leaden pipes, &c.

"It is also valued for its indestructibility by wet, moisture, &c.; its peculiar power of resisting frost; the great lengths in which it can be made (50 to 500 feet) without a joint; the ease with

which the requisite joints can be made; and its extraordinary power of conducting sound.

"Gutta percha tubing is consequently applicable for the following purposes:—

"The conveyance of water, oil, acids, and other chemicals, liquid manures, &c.; drain and soil pipes; suction pipes for fire-engines; pump barrels and feeding-pipes; ship pumps; syphons; ventilation, &c. of mines, public buildings, &c.; for watering gardens and streets, washing windows, damping floors, &c.; ear and speaking trumpets; speaking tubes for warehouses, dwelling-houses, ships, &c. in lieu of bells; for enabling deaf persons to hear sermons, &c."

For the conveyance of water, its extraordinary strength is shown by the following results obtained at the water-works, Birmingham:—Pieces of gutta percha tubes were placed at the end of service-pipes, where the constant pressure was above 200 feet head of water, and where the ram, caused by the shutting off the flow of water suddenly, was consequently very great. These experiments have been attended with perfect success, so far as the capability of these pipes to withstand hydraulic pressure, whether steadily or intermittently applied, is con-

cerned. The tubes were $\frac{3}{4}$-inch bore, the material $\frac{1}{8}$th thick; and in addition to the trial above named, they were also tested by the water company's proofing pump, with its regular load of 250 pounds to the square inch—afterwards weight was added up to 337 pounds, and it was wished to have gone to 500, but the lever of the valve would bear no more weight; they were, consequently, unable to burst the pipe. A strong man worked the pump as quick as he could, and the pulsations in the pipe were very distinct; but owing to the slight elasticity of the gutta percha, no permanent effect could be discovered. The joints were very simply and easily made, and stood perfectly tight.

At Stirling a still more conclusive evidence of the singular strength of these tubes has been given. The pressure of water in that town is higher than in any other in this kingdom; the head of water being upwards of 450 feet high. This enormous pressure was withstood by the gutta percha without visible token of injury, while leather hose, strongly riveted, is rent asunder by it almost immediately, the rivets flying out, and the joints bursting.

An experiment, on a very extensive scale, for

the conveyance of water by this material, has been made in America. The following is the account given of the experiment, in a New York journal:—

A gutta percha pipe of $2\frac{1}{2}$ inches calibre, and 1,000 feet in length, has been laid down for conveying the Croton Water to Blackwell's Island, New York. The line extends from the foot of Seventy-ninth-street to the island, the depth of the water varying from thirty to seven feet. The engineer first arranged his pipe in one length upon the island, and formed a line of thirty boats, well manned, across the river. He then gave his order, at the commencement of slack water, and the end of the pipe was drawn across the river by men upon the opposite shore, and was taken up by the men in the boats, and 110 anchors, each weighing thirty-two pounds, were attached to the pipe, being ten feet apart. By word of command the men in the boats lowered at each point to suit the inequalities in the bed of the river, as ascertained by previous survey. This was all accomplished in seven and a half minutes, without accident.

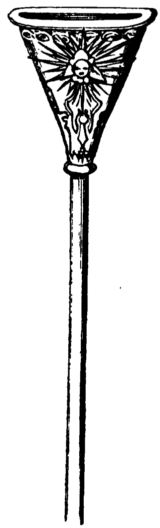
This tubing is also extensively employed for conveying gas for temporary purposes, as the occasional illumination of large apartments. It is

ingeniously converted into a portable gas lamp, in the following manner:—" Gutta percha tubing may be made available for portable gas lamps, which can be carried in the hand to any part of the workshop. By coiling the small tubing round a wood cylinder (similar to the tape measures), and attaching a few inches of metal pipe and a jet to one end, and securing the other end to the gas pipe, a light may be carried about at pleasure."

As some of our readers may wish to make this experiment, it may be useful to add the " Directions for attaching Gutta Percha Tubing to Metal," given by the manufacturers:—" Soften the end of the gutta percha tube in hot water—wipe off the moisture, and then stretch it over the end of the metal pipe. Keep very gently and constantly pressing the gutta percha to the metal with the palm of the hand until it is *quite cold* (which may be hastened by the pouring on of cold water), and it will form a perfect joint. No bandage or wrapping will be required, if properly done, as the gutta percha in cooling *gradually contracts*, and thus *bites*, or firmly grasps the metal tube."

We have used this material for gas for some time, but it has appeared to undergo some change

under the continual influence of the coal gas, becoming darker in colour, and apparently in a slight degree permeated by the gas. It would seem, therefore, to be more suitable for a temporary than for a permanent purpose.



Certainly one of the most remarkable properties of this tubing is its extraordinary power of conveying sound. The ticking of a watch has been distinctly heard at a distance of 450 feet! Perhaps one of the most singular uses of it in this way has been the communication established between the top and bottom of deep mines. At a coal-pit in Monmouthshire a speaking tube, 400 feet long, has been fixed so that the miner can summon the engineman, or hold conversation with him with complete freedom, although separated by this great depth. For churches an ingenious arrangement is adopted. A gutta percha funnel (see cut) is placed either inside (so as to be completely out of sight of the congregation), or in front of the

pulpit,* to which the tubing is attached, and carried under the woodwork or floor, to the pew in which the deaf person sits. The end of the tube (which is all that appears) is applied to the ear. The softest whisper in the pulpit is distinctly heard in the pew, when the ear is applied to the ivory terminal.

At Lismore Cathedral such tubes are conveyed from both pulpit and reading desk to the Duke of Devonshire's pew (under the flagging and flooring, and altogether out of sight), and although their length is between thirty and forty feet, he is able with their assistance to hear distinctly every word of the service and sermon.

The result affords a very satisfactory proof of the extraordinary power which gutta percha possesses for the transmission of sound, as without the apparatus, the voice of either reader or preacher is quite inaudible to this nobleman.

A gutta percha hearing apparatus was fitted up in Exeter Hall, at the annual meeting of one of the religious societies, and answered admirably. A lady, who had not heard a sermon for more than

* Ornamental funnels are provided, suitable for the fronts of the pulpits; one of these is shown in the cut.

twenty years, was enabled to listen with pleasure, and with peculiar feelings of thankfulness, not only to the speeches, but to every word of the lengthy report; notwithstanding that she sat at a considerable distance from the speakers. When the great size of the room, and the number of persons present (about 4,000) is borne in mind, the success of the apparatus is very interesting.

For medical men, tubes of this material are very useful for midnight conversation with patients outside. A number of clever acoustic instruments have also been made of gutta percha, such as ear trumpets, speaking trumpets, stethoscopes, &c.

It is also useful in various ways for splints, and a group of these, which might have been seen at the Great Exhibition of 1851, is shown in the annexed cut.

The cause which appears to confer this peculiar property on gutta percha has not yet been distinctly stated; but it appears to us to lie in the non-vibratory character of the walls of the tube. Noises from without have thus little effect on the passage of the sound. Pipes of tin or wood are easily thrown into vibration by any sound external to them, and the communication of the sound

within would thus appear to be materially interfered with.

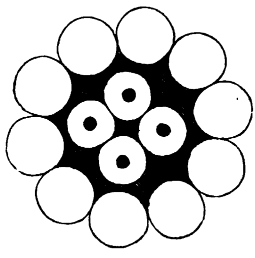
As a domestic telegraph, gutta percha tubing is equally valuable; and an arrangement for this

ARTICLES IN GUTTA PERCHA.

object, of an ingenious kind, has been invented by a Mr. Whishaw. To this the uncouth name of the Telekouphanon has been given. It is simply a

gutta percha tube, with a mouth-piece at each end, to which a whistle is fitted. When it is desired to call attention, the whistle is removed, and the person blows into the tube. This causes the whistle at the other end to sound, and thus directs the person to the tube, through which the order is conveyed. It is said that a conversation could be carried on without difficulty at three quarters of a mile, or even a mile.

We have already alluded to the insulation of electric telegraph wires by gutta percha; and this constitutes one of its most valued and important purposes—for, by its assistance, even the sea is no longer an obstacle to the instantaneous transmission of intelligence. The wires are generally protected by an outer coating of tarred rope, and over this by a coating of galvanised wires. The cut exhibits the appearance of a section of the submarine wires between England and France, taken from a piece sent to the writer by the Gutta Percha Company. The four central



SUBMARINE WIRE.

dots represent the all-important copper wires, surrounded by their covering of gutta percha; at the circumference are seen the galvanised iron wires intended to protect the rope from injury.

It appears, from various experiments, that gutta percha is not affected by wet, or salt water. The telegraphic engineer of one of the large railways states that more than forty miles of the gutta percha covered wire, for electro-telegraphic purposes, have been laid down on the London and North Western Railway. Of this quantity, about fifteen miles have been placed underground. A portion of the wire has now been in constant use for nearly a year and a half. Up to this period, the protective influence of the gutta percha covering has been perfectly satisfactory.

For experimental purposes, some of the gutta percha covered wire has been laid in the German Ocean. It was submerged in the sea for more than a year. Where the wire was placed, marine insects eat away and completely destroy pine timber, of great thickness, in less than seven years. The gutta percha covering to the wire, however, remained intact, although a portion of it was fastened to timber, which, owing to the

ravages of these insects, had already been renewed.

In order to ensure the perfect insulation of the covered wire, it is always tested at the works. On all sides of a barge floating in the canal are seen coils of this wire, on some occasions amounting to as much as 160 miles, which are placed there for the purpose of ascertaining their condition as to insulation. A small electro-magnetic needle is placed in a little office adjoining, and a current of electricity sent through the wire. By its effects on the needle, it can be ascertained whether or not its insulation is complete.

An ingenious method of discharging gunpowder for submarine blasting, by the aid of this wire, has been described in the *Army and Navy Register* for August 1851. "On Monday, August 18th, some interesting experiments were tried at the Gutta Percha Company's Works, Wharf-road, City-road, for the purpose of demonstrating the means by which this extraordinary production may be applied to the operation of discharging gunpowder. A galvanic battery was connected with upwards of fifty miles of copper wire, covered with gutta percha to the thickness of an ordinary

black lead pencil. This wire, which was formed into coils, and which was prepared for the projected submarine telegraph, was attached to a barge moored in the canal alongside the manufactory, the coils being so fixed together (although the greater portion of them were under water) as to present an uninterrupted communication with the battery to a distance limited at first to fifty-seven miles, but afterwards extended to seventy.

"A 'cartridge' formed with a small hollow roof of gutta percha, charged with gunpowder, and having an intercommunicating wire attached, was then brought into contact with the electric current. The result was, that a spark was produced, which, igniting the gunpowder, caused an immediate explosion, similar to that which would arise from the discharge of a small cannon. The same process was carried out in various ways, with a view of testing the efficient manner in which the gutta percha had been rendered impervious to wet, and in one instance the fusee or cartridge was placed under the water. In this case the efficiency of the insulation was equally well demonstrated by the explosion of the gunpowder the moment the necessary 'contact' was pro-

duced; and by way of showing the perfect insulation of the wire, an experiment was tried which resulted in the explosion of the fusee from the charge of electricity retained in the coils of wire, three seconds after contact with the battery had been broken. This feature in the experiment was especially interesting from the fact of its removing all difficulty and doubt as to whether the gutta percha would so far protect the wires as to preserve the current of electricity under the most disadvantageous circumstances.

"Another experiment was successfully tried by passing the electric current to its destination through *the human body*. A gentleman volunteered to form part of the circuit by holding the ends of thirty-five miles of the wire in each hand. The wire from the battery was brought to one end of the entire length of seventy miles, and instant explosion of the cartridge took place at the other end.

"The experiments were altogether perfectly successful, as showing beyond all question that the properties of gutta percha and electricity combined are yet to be devoted to other purposes than that of establishing a submarine telegraph. The blasting of a rock, the destruction of a fortifi-

cation, and other operations which require the agency of gunpowder, have often been attended with considerable danger and trouble, besides involving large outlays of money; but it may be truly said that the employment of electricity in the manner described is calculated to render such operations comparatively free from difficulty. It is impossible to foretel the value of this discovery, particularly in engineering and mining operations."

For the electrotypist, gutta percha appears to be very useful; and the following account has been published of the method of obtaining a mould of this material. Small objects, as seals, may be impressed directly, as upon sealing-wax, the gutta sheet having been sufficiently softened by heat; larger ones, not very high in relief, should be first warmed, placed on a flat surface, and sheet gutta percha, previously dipped until it becomes quite soft into boiling water, laid carefully on them, pressed with the hand into contact with their surface, and the whole then transferred to a press, and kept there until nearly cold. In default of a screw-press, heavy weights may be used to effect the object.

Printing type, wood blocks, and engraved plates, may be copied in the most perfect manner by

this means, without risk of injury to the originals. In the case of type great pressure should not be employed: the gutta, being forced too far into the interstices between the letters, forms such depressions in the mould as obstinately retain air-bubbles, and thus prevent our obtaining a perfect cast adapted to printing. If the object be in high relief, the following method is the most eligible for copying its details:—Let the gutta be boiled in water until quite soft, then carefully freed from moisture by pressure in a cloth, rolled into a ball, and assiduously pressed with the hand into all the sinuosities of the model, commencing in the centre, and gradually extending the pressure, so as to drive the air before it, until the edge is reached, when it may be transferred to the press, or heavy weights placed on it as before mentioned. Those French cigar and card cases, purses, &c., ornamented with electro-silvered copper casts, which have been lately introduced into commerce, appear to be produced from gutta percha moulds; and if this be the case, they form a very fine illustration of the capabilities of this substance in the application of the electrotype to practical purposes.

Galvanic copies of leaves, ferns, and other vegetable productions which can be laid on a flat surface and submitted to gentle pressure, are easily obtained, and reproduce the object with great fidelity. The utility of gutta percha in the copying of rare fossils was beautifully displayed in the Austrian portion of the Great Exhibition.*

The application of gutta percha to the production of stereotypes was also shown at the Exhibition, among the machinery in motion. The matrix is taken, as above described, by pressure from the block of types while the sheet of gutta percha is hot and soft, and a sharp and fine impression is obtained. When cold and hard, this stereotyping plate of gutta percha is ready to have a like impression, or reverse of itself, taken also, by pressure of a second soft and moist sheet of gutta percha on *it;* and this, when cold and hard, is ready at once for the press, plate, or cylinder. The specimens of printing from letters and engravings thus formed are as sharp as if taken in metal, and the flexible nature of the substance admits of its being curved round a cylinder, to adapt the surface more completely to the action of the cylinder printing-

* Chemical Record, No. 42.

machine. The gutta percha type is even stated to be very durable, and to possess the advantage of printing the impressions on dry and even on glazed paper. This novel application of gutta percha, if it realize the expectations of the inventor, promises to be an important addition to typographic art. We have, however, been informed that as yet its practical application has not been successful to the extent originally contemplated.

Its uses for chemical purposes are extremely varied, and extend to the manufactory as well as to the laboratory. It supersedes in alkali works the vessels and instruments of iron formerly used,—the iron ladles, pump-barrels, the leather clacks and buckets, spouts, &c. Though carbonized by concentrated sulphuric acid, for acid of ordinary strength this is of less consequence; and at the Bristol vitriol works it is used in the pumps for buckets, instead of leather, and is found more economical; as, while the very best leather required renewing twice a-week at least, the gutta percha will endure the same wear and tear for three months without any repair. For dilute nitric acid, it is used by the gold refiners to line the various vessels used in the

refining process; and by calico-printers to cover the rollers on which the patterns are etched, an application for which it is well adapted. Its resistance of the action of iodine and bromine enables the daguerreotypist to use it for his iodizing and bromine pans; an application particularly valuable to those photographers who are continually complaining of the damage and breakage to which their apparatus is subject. For fluoric acid it will make excellent bottles, in the place of the lead bottles, which were almost as often to be found empty as full, if kept long in stock. But of all chemical processes, that to which it is best adapted, and for which it is coming into most extensive use, is that of holding muriatic acid, instead of glass carboys or leaden cisterns. This application was made at the suggestion of the manager of a Patent Candle Company, where large quantities of this acid are used, and which had to be carried in glass carboys from works in Liverpool. Several wine-pipes were lined, and carboys made, which have answered the most sanguine expectations; and now there are continually pipes of muriatic acid travelling along the railways! For vinegar casks, and oil cisterns, it might be advantageously em-

ployed; for funnels, syphons, capping for jars and bottles, &c., it answers well.

The sheet gutta percha is coming into extensive use as a substitute for sheet lead as a lining for cisterns. The simplicity of this application is quite remarkable. If we suppose a wooden cistern thus to be treated, five pieces of sheet gum are cut to the sizes for the bottom and sides: these being held temporarily in their places, bands or strips of gutta percha are softened in hot water and laid along the joints, to which they are firmly united by the application of a hot iron. The principle, indeed, is that by which the plumber solders two sheets of lead together; but the process is altogether much more facile and expeditious. For ordinary cisterns, the thickness somewhat exceeds an eighth of an inch, and such a sheet weighs six to eight pounds per square yard. There is thus a cistern within a cistern, for the gutta percha does not adhere to the wood; the wood, in fact, acts simply as a case or envelope, to keep the real cistern in shape.

The application of gutta percha to wheel-bands for machinery deserves remark. When a shaft or wheel is rotating, another shaft or wheel at a con-

siderable distance may be made also to rotate, by carrying an endless band from one to the other, and making it coil tightly round both; the first wheel causes the band to rotate, and this in its turn communicates similar motion to the second wheel. These bands, until of late, have generally been made of leather; but gutta percha is found to possess many qualities available for this object. A strip of the required width is cut from the sheet, and the two ends of this strip are joined, so as to form an endless band. The qualities which seem to adapt this material for such purposes are the durability and strength, the permanent contractibility, the uniformity of substance, the power of resisting water, acids, alkalies, oil, and grease, and the facility of making joints. These bands are now used to a considerable extent in breweries, bleach and dye-works, cotton and woollen-factories, iron-works, paper-mills, corn-mills, brick-yards, and other large establishments where much wheel-work is employed.

With one further extract we must bring our notice of the applications of this all-useful material to a conclusion.

The late expeditions in search of Sir John

Franklin have proved the value of gutta percha in a remarkable manner. Each of them took out sledge boats of this substance for use among the masses of ice. Fitted with a skate, the boat served as a sledge; floated, it would carry five or six persons with ample provision; at other times it might be folded up, or converted into a wrapper or bed-tent, safe against the cold, that three or four men might sleep under. Its weight was only *eighteen pounds.* The captain of "Lady Franklin's Expedition" stated that "the gutta percha boat proved an invaluable acquisition." After undergoing all the rough work of the voyage, "it returned to England not in the least damaged, and in almost as good condition as when she left." For ordinary life-boats gutta percha must prove very useful. Beside their buoyancy, they cannot be stove in by rocks, &c.

Mr. Snow, who went out in the Prince Albert Expedition, has given a most favourable report of the gutta percha boat used in that expedition, which we extract from the *Illustrated London News* of February 22d, 1851.

"The value of Gutta Percha as an article applied to boats, could, perhaps, never have been

better tested than during the late voyage of the 'Prince Albert' in search of Sir John Franklin; and I feel very great pleasure in giving my humble testimony to its undoubted merits. Having, in almost every instance, had charge of the gutta percha boat,* in the various examinations of the coast we made, and in rough passages through the ice, I had good and ample opportunities of giving her a fair trial, and the result was highly satisfactory. As this was an article with which I had previously been but little acquainted, I was at first cautious in the extreme, whenever I was away in that particular boat; but at last, I preferred her to any other, and would not have hesitated to have gone any distance for any length of time in her. The men (old whalers, long accustomed to the ice) in like manner gave her the preference, and considered her far superior for such service to the ordinary boats generally used.

"The first trial she received was off the Greenland coast, when we were surrounded by icebergs.

* "The wooden work of this boat was constructed by Messrs. Searle and Co. of South Lambeth. The covering with gutta percha was done at the Gutta Percha Company's Works, Wharf Road, City Road, London."

I proceeded in her to a large berg, for the purpose of procuring water, and it was found that she pulled lightly, and swam as buoyantly as we could wish. The various pieces of ice that she unavoidably ran against did her no injury, and they glided past her without leaving the slightest indentation or mark of the contact.

"On the night of the 17th July I again had an opportunity of testing her qualities. In searching for the Danish settlement of Upernavick, I proceeded in her for several miles through the various inlets and channels abounding in the 'Woman Islands.' On one occasion I had her pulled up high on the rocky beach, while landing to examine, and I could not perceive the slightest mark of a scratch, from the rough nature of her bed, such as an ordinary boat would have received if I had attempted the same with it. Upon returning to the ship, we ran through a small stream of rather close ice, and I was agreeably surprised to find how quietly the gutta percha appeared to slip through it, and how well it resisted the different attacks it received. As a memorial of our visit, and the value we attached to the article of which our boat was made, the inlet we

were then making our way through was called 'Gutta Percha Inlet;' a name it will no doubt always retain, and be remembered by among whalers.

"Frequently after this the boat was in use, and principally among heavy ice. Indeed, when one boat alone was required, the gutta percha boat was that invariably used. Every one saw its superiority to the ordinary boats; and it was kept incessantly at work, boring, breaking, and crossing the ice at all times.

"But the severest trial it endured, and endured successfully, was on both my visits to Whaler Point, Port Leopold. To those unaccustomed to the nature of such ice as was there met with, it will be impossible fully to conceive the position a boat was placed in. The mere transit to and fro among loose masses of ice, with the sea in a state of quiescence, would have been quite enough to have tested the value of gutta percha boats; but when, as in the present case, these masses were all in restless agitation, with a sea rolling in upon an opposing current, it might have been well excused—and without deteriorating from the previously attested goodness of the article—if it had

not resisted the severe shocks it received. My first visit was difficult enough, but the second was far worse; and nothing but the exigencies of the service would have warranted me in attempting to force a way as I did. My dependence, however, was upon the already well-tried qualities of the boat. Sliding through and over the ice; sometimes lifted completely out of the water by the sudden contact of a restless floe, and at others thrown sideways upon an adjoining craggy piece, I think it would have been next to impossible for any other kind of boat to have been otherwise than crushed or stove on the instant."

In detailing these applications of this extraordinary material, we have merely selected a few of the most interesting, and of those which are well authenticated. Gutta Percha enters, however, into every part of our domestic, as well as social, philosophical, manufacturing, and engineering requirements. It is not less useful in the form of soles to our shoes, than in that of bands and tubing. In an ordinary sitting-room it might form the curtain rings, the window cords, the picture cord, the lining for the walls, the inkstand and pen-tray, the watch-stand, card-basket and

bracket, the ornaments for the sideboard and for the ceiling, the speaking-tube to the kitchen, and the gas-pipe to the table—in short, it is a substitute for wood, glass, metal, string, and porcelain. And now that the advantages it confers are appreciated, we should greatly miss its presence if, from some unexpected cause, the supply were cut off, and this universally serviceable material denied to our use.

THE END.

R. CLAY, PRINTER, BREAD STREET HILL.